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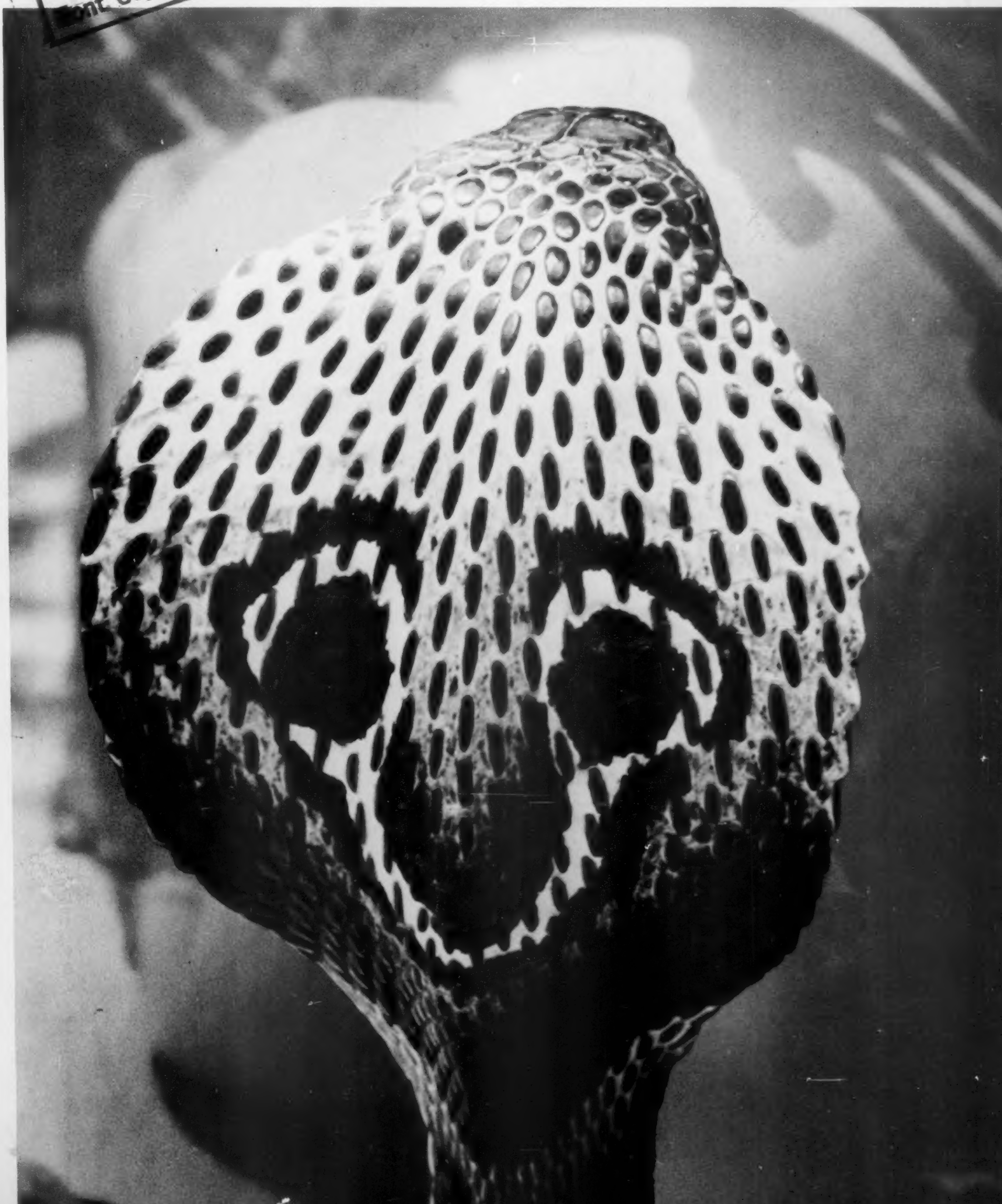

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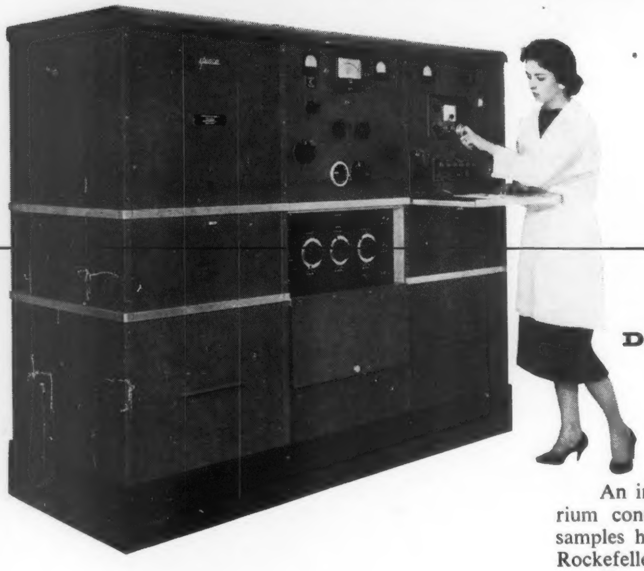

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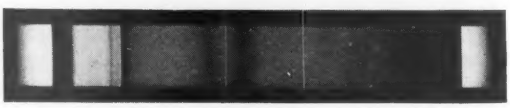
Macromolecules of nearly identical density can be separated and measured by the powerful, rapidly developing technique of density gradient ultracentrifugation. A solution such as cesium chloride is centrifuged with the sample and a concentration gradient created in the cell by centrifugal force. The macromolecules of sample seek the level in the cell corresponding to their own density. The resultant discrete bands can be photographed by absorption optics.



An example of the extreme power of this method is shown here in the separation of DNA's, one containing N_{14}, the other N_{15}.

A summary of density gradient techniques for both analytical and preparative ultracentrifuges has been published by Spinco and copies are available on request.

Sedimentation of High Polymers

Of special interest to polymer chemists is a comprehensive summary on sedimentation of synthetic and natural polymers by R. L. Baldwin of the University of Wisconsin (now at Stanford) and K. E. Van Holde of the University of Illinois. The authors discuss in detail the kinds of information obtainable by ultracentrifugation, and methods used. An appendix lists polymers run on the Ultracentrifuge, solvents, and literature references.

The work appeared in the first issue of the German journal "Advances in Polymer Science"; reprints (in English) are available from Spinco.

If you are not familiar with the Ultracentrifuge, we will be happy to send you copies of "An Introduction to Ultracentrifuge Techniques" and the latest issue of "Fractions", a periodical sent to owners of Spinco ultracentrifuges, electrophoresis-diffusion instruments and amino acid analyzers. Write Beckman Instruments, Inc., Spinco Div., Stanford Industrial Park, Palo Alto 5, Calif.

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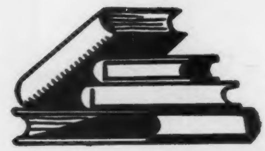

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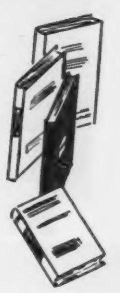

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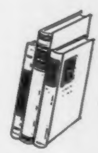

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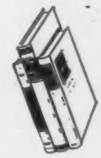

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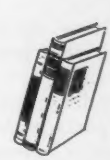

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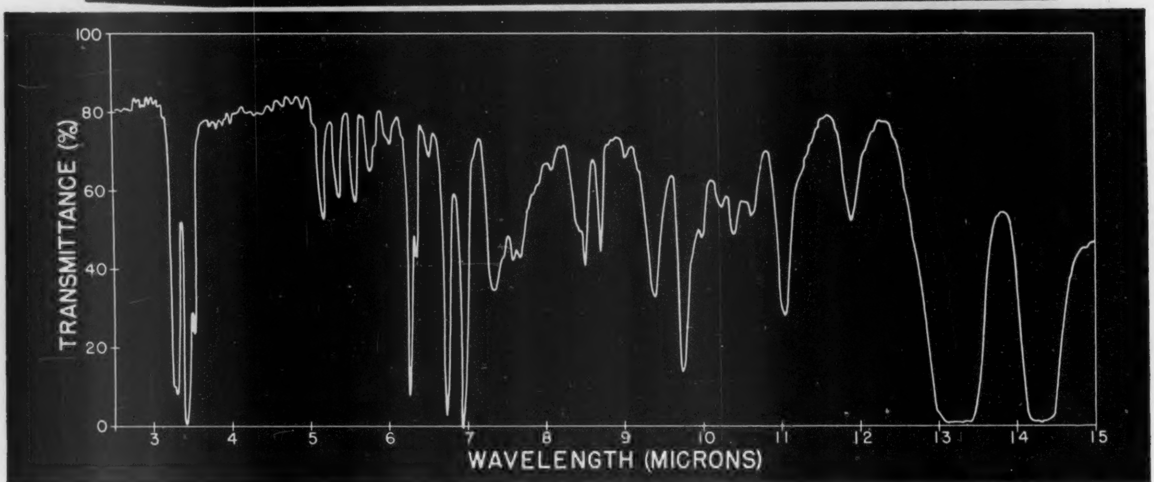

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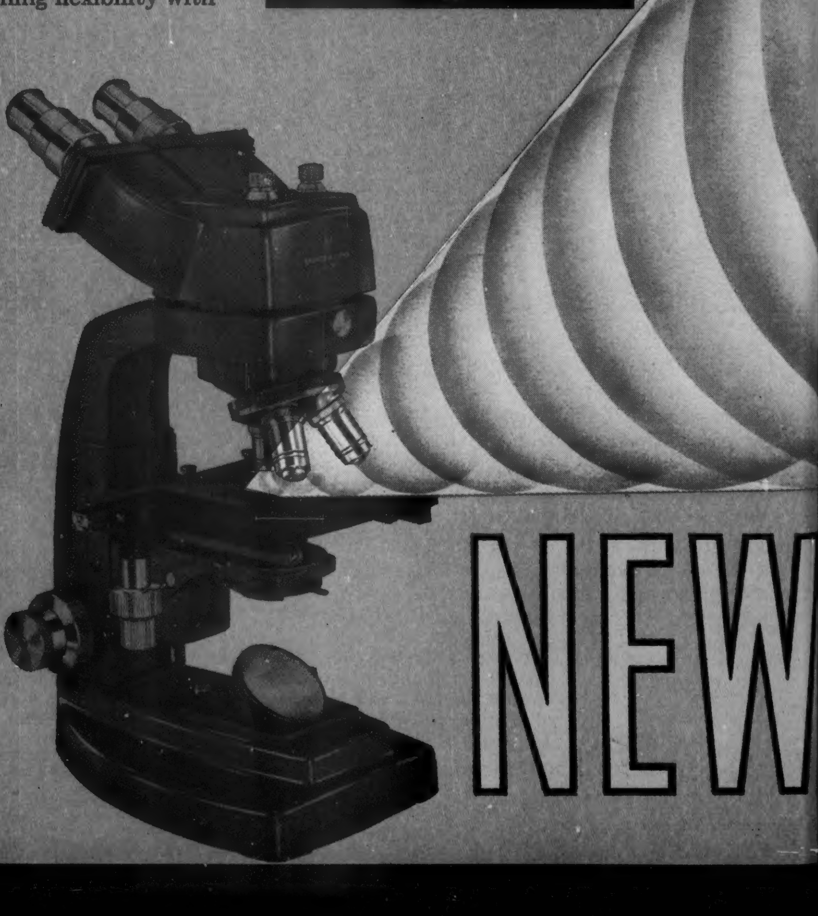

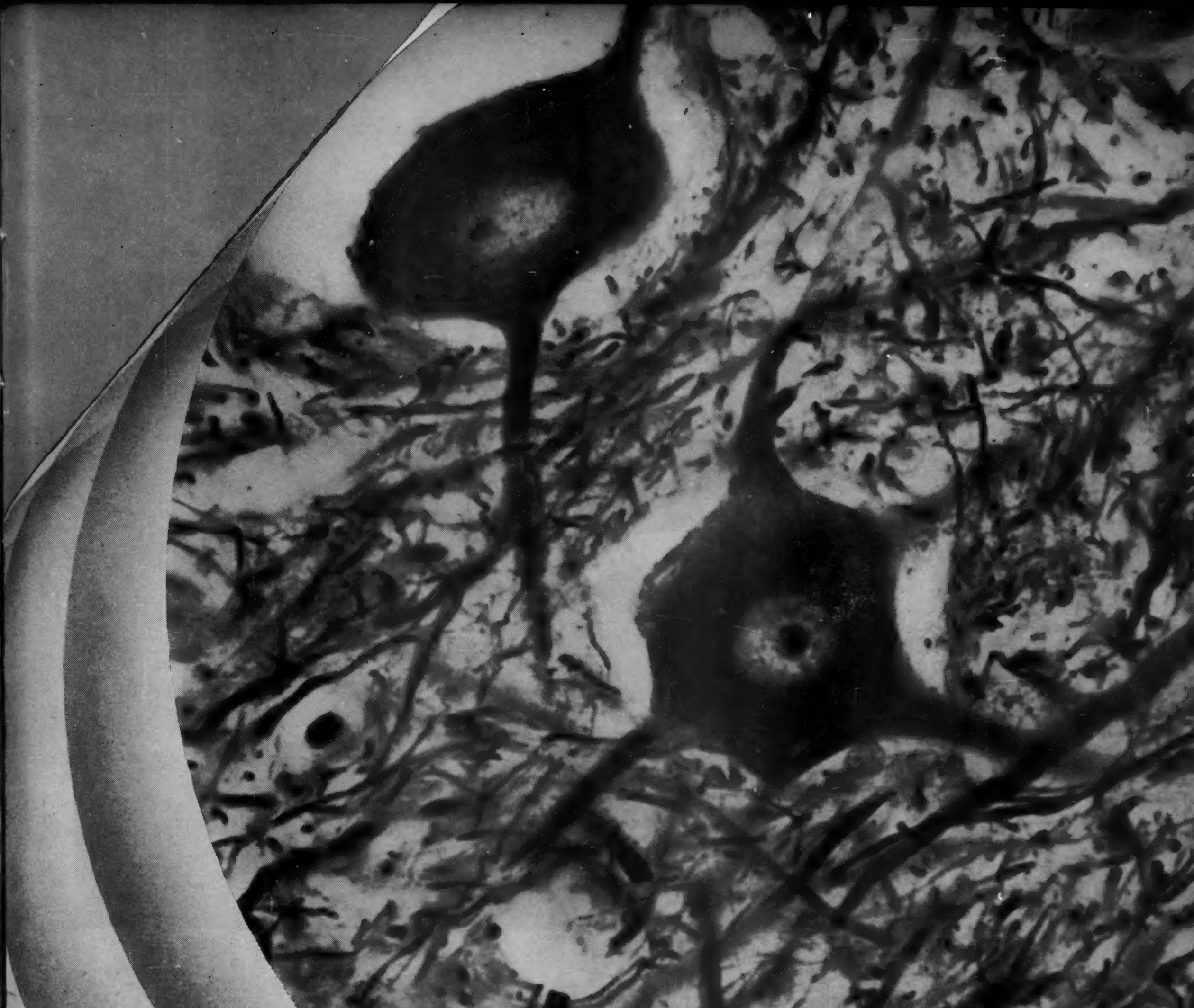

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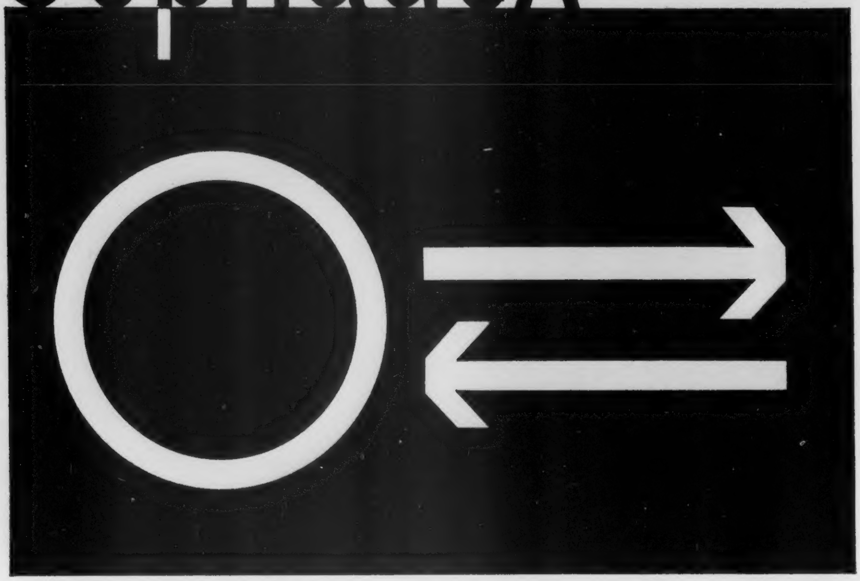

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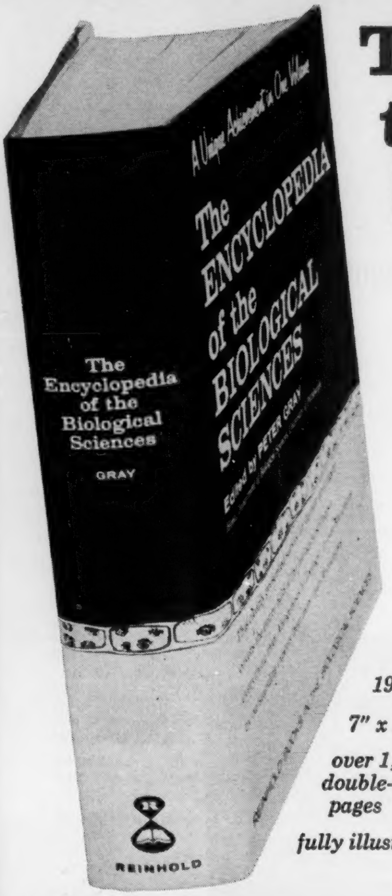

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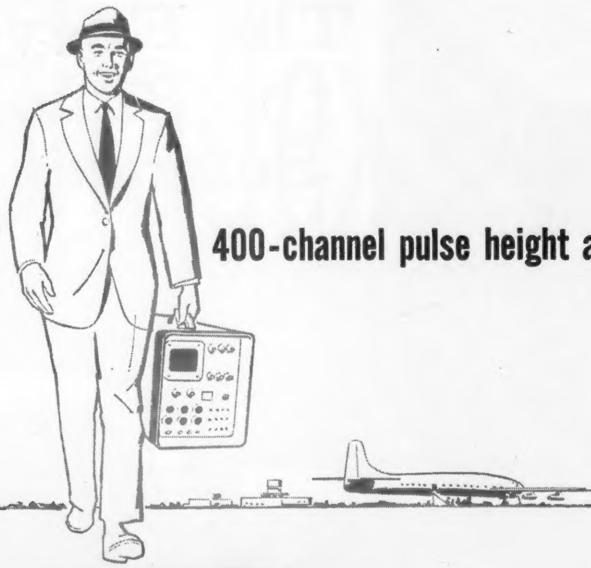

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Unhappy Paradox

Modern agricultural production is a triumph of the application of knowledge derived from basic research to problems of human nutrition and welfare. During the past quarter century agricultural practice has undergone a full-scale revolution as a result of the integrated application of many technologies to the total problem of crop and animal production, nutrition, protection, and utilization. Advances in the engineering, chemical, physical, and biological sciences have in the most highly developed countries of the world permitted qualitative and quantitative improvements in agricultural production in new orders of magnitude and at the same time have pointed the way to future improvements of similar or even greater dimensions.

The secret of this success story lies in men rather than machines. The outpouring of trained scientists and others destined to work in some aspect of agriculture has made possible extraordinarily creative and exceedingly rapid advances in science and technology. The agricultural producers in the industrial countries are highly sophisticated groups who have taken full advantage of available knowledge and tools, with the result that production has steadily increased, while manpower requirements and costs have simultaneously declined. Thus, today the citizens of Western and certain other nations are able to enjoy appetizing, high-quality, and nutritious domestic and exotic foods without seasonal limitations and at reasonable prices. However, regardless of past achievements, it is entirely clear that future advances in response to the demands of a growing population are going to require more extensive and greatly intensified scientific research and development.

With the knowledge and tools now available to society for the satisfaction of agricultural requirements, it seems paradoxical that a large proportion of the world's population lives at substandard nutritional levels. It is frequently suggested that the massive application everywhere of modern technologies could readily eliminate the specter of hunger which stalks so many lands; theoretically, such massive application could be carried out, but in practice this is impossible.

The great barrier is now, and will continue to be for a substantial period in the future, the lack of sufficient numbers of nationals able to participate in research and to contribute otherwise to the development and application of technologies in support of progress on all fronts. Thus, the future economic growth of many of the less well-developed nations of the world will depend precisely upon the rapidity with which their citizens can be trained for the multiplicity of responsibilities related to agricultural production, distribution, marketing, and utilization and attendant occupations.

Friendly nations cannot resolve the problems of the less well-developed or emerging countries, but they can help to speed the processes of social and economic growth. Efforts should include industrial and engineering projects, but more fundamentally they must emphasize education at all levels. Especially important is the utilization of technical assistance programs as intensive training media. Training abroad for special purposes is vitally important, but the broad base for economic growth and social progress is to be found at home, through interrelated programs designed to prepare growing numbers of nationals to respond to the demands of evolving social patterns.—J. G. HARRAR, *Rockefeller Foundation, New York.*

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CURRENT PROBLEMS IN RESEARCH

Volcanology

Volcanoes furnish some of our best clues to the nature of the earth's interior.

Gordon A. Macdonald

A volcano is commonly defined as a place where molten rock (magma) and gases issue at the surface of the earth, or as the hill or mountain built up around that vent by the escaping material. But volcanology, the science of volcanoes, goes beyond these surficial structures and the processes that take place at and around them and concerns itself also with the structures and processes within the earth that give rise to the surface phenomena. Indeed, volcanoes are one of our principal windows to the earth's interior; the composition and condition of materials issuing at volcanoes supply our best direct evidence as to the nature of the rocks and the processes that go on within the earth below the very thin rind that is known to us from direct observation. Less than 0.3 percent of the radius of the earth is directly visible to geologists, even in the deepest drill holes and the most deeply eroded mountain belts. All the rest must be studied by indirect methods, such as seismology, and by inference from things observed in the visible surficial film and at volcanoes. There is today a tendency to include all magma chemistry within volcanology, perhaps partly because of the growing realization that many of the deep-seated, "plutonic" rocks traditionally considered to be igneous—that is, to have consolidated from a molten state—actually have never been molten. There can, however, be no question that the molten lavas poured out at volcanoes represent real magmas.

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At any rate, today volcanology includes the study not only of volcanoes per se but of all even remotely related things in the earth beneath.

In a sense, volcanology is a very old science. The ancients had an intense, partly superstitious, interest in volcanoes. The great Roman natural historian, Pliny the Elder, lost his life on an expedition undertaken in part to study the great eruption of Vesuvius in the year A.D. 79. (Eruptions of that type are now called Plinian eruptions.) Nevertheless, modern volcanology is very new. Classical volcanology was almost wholly descriptive. A great mass of information was collected on the physical nature of lavas and the structure of volcanic mountains, but the relatively small amount of interpretation of these facts was almost wholly speculative. Within the last half century the emphasis in volcanology has shifted to interpretation. We are now trying to deduce the processes that must have gone on within the earth to produce the results we see at the surface.

That this interpretive phase was so long delayed is the result of two general factors. First, volcanic eruptions are relatively infrequent and the physical difficulties of studying them at close range are great, and therefore it has taken a good deal of time to accumulate sufficient information on which to base interpretations. Even more, however, the delay has been the result of the border-line nature of volcanology, which depends very heavily on other sciences, particularly physics and chemistry. Interpretive volcanology of necessity had to await the development of physical and chemical methods and theory.

Current Problems in Volcanology

The major problems in volcanology are today, as they always have been, the origin of volcanic heat, the locus and means of origin of magma, the mechanics of rise of magma to the earth's surface, the processes that give rise to the considerable range in composition of magmas that reach the surface, the subsurface structure of volcano systems, and the origin of the water that forms the major portion of the volcanic gases.

There are, of course, a host of other, lesser problems, only a few of which can be mentioned here. As examples I might cite the mechanics of formation of large sunken-in craters, or calderas, such as that of Crater Lake, in Oregon; the mechanics of lava flow and the effects of flows on objects they encounter; the physical properties of lavas and magmas; the mechanics of volcanic explosion and the formation of volcanic ash; and the mode of eruption and emplacement of certain sheets of rock, commonly of vast volume and extent, that partake of the characteristics of both lava flows and volcanic ash.

In another class fall the practical applications of volcanology: the utilization of volcanic heat, either directly or as steam, for heating and—vastly more important—for generation of power; the appraisal of risk from volcanic activity to persons and property; the prediction of time and type of eruption; the control of lava flows and volcanic mud flows. Ignored by some scientists, these practical problems are of tremendous importance to the millions of persons living on and near active volcanoes and form a link be-

Table 1. Compositions of basaltic and peridotitic rocks (percent by weight). (1) Average tholeiitic basalt of the Deccan region, India (Holmes and Harwood, 1928); (2) average tholeiitic basalt of the Hawaiian Islands (Kuno *et al.*, 1957); (3) average alkali basalt, Hawaiian Islands; (4) average high-alumina basalt, northeastern California; (5) eclogite, Glenelg, Scotland (Yoder and Tilley, 1959); (6) average of silicate phase of stony meteorites (Brown and Patterson, 1948); (7) average dunite (Wager, 1958).

Rock	1	2	3	4	5	6	7
SiO_2	49.7	50.9	46.7	50.9	50.0	46.2	41.9
Al_2O_3	13.0	13.2	14.4	17.5	13.4	3.4	1.1
Iron as FeO	13.2	10.9	11.9	8.5	13.7	17.0	7.3
MgO	5.7	8.0	8.8	8.3	6.5	27.6	46.2
CaO	10.1	10.6	10.6	10.2	11.0	2.9	1.1
Na_2O	2.3	2.2	3.0	2.9	2.4	1.1	0.1
K_2O	0.5	0.4	0.9	0.5	0.4	0.2	0.005
TiO_2	2.6	2.8	3.0	1.0	1.6	0.2	0.1
P_2O_5	0.3	0.3	0.4	0.2	0.1	0.4	0.1
MnO	0.2	0.1	0.1	0.2	0.2	0.4	0.1

tween the science of volcanology and volcano technology.

There is not space here to discuss all of the problems of volcanology, or even to discuss any of them really adequately. I shall attempt merely to present a brief review of some of the more basic ones, and to indicate something of the complex interplay of various scientific disciplines within the field of modern volcanology.

Origin of Magma

The earth's crust is a thin shell, about 20 to 60 kilometers thick beneath the continents and as little as 3 kilometers thick beneath the oceans. Beneath the crust lies a much thicker shell, known as the mantle, that extends to the boundary of the core at a depth of 2900 kilometers. The molten rock, or magma, that is erupted at volcanoes is generally believed to originate in the outer part of the mantle, but we actually have little direct evidence of just where or how it is formed.

For a quarter of a century we have recognized earthquakes stemming from a zone about 40 kilometers deep below the Hawaiian volcanoes (about 35 kilometers below the top of the mantle in that region), and it has been presumed that the magma originates there. In recent years, with the installation of more sensitive seismographs, there has been found associated with the earthquakes a rhythmic trembling of the ground, known as volcanic tremor. This tremor has long been known to arise also in a zone near the surface, where it quite definitely accompanies the movement of molten rock in the volcanic conduits. Thus, recognition of volcanic tremor in association with earthquakes from the 40-kilometer zone tends to confirm the belief that moving magma is present at that level. In the absence of better evidence, we are assuming that Hawaiian magmas come from that depth. Seismological evidence also suggests that magma is formed at or near the top of the mantle, at a depth of 50 to 60 kilometers, beneath the Kamchatkan volcanoes.

Near the surface, temperature increases downward within the earth at an average rate of about 1°C per 30 meters. It seems quite certain that this rate of increase does not continue to great depths, but just what the rate is beyond the outermost few kilometers is highly speculative. No direct measurements are available, and estimates are strongly influenced by such theoretical considerations as the assumed mode of formation of the earth, the origin of the earth's heat, and the composition and physical properties of the mantle and core. Most estimates, however, place the temperature at a depth of 200 kilometers, between 1400° and 1750°C. One of the latest estimates (*1*) envisages a steep temperature gradient near the surface, reaching 1100° or 1200°C at 100-kilometer depth and about 1500°C at 200 kilometers and then flattening to about the adiabatic gradient through the rest of the mantle. This and other recent estimates are shown in Fig. 1. These estimates are, of course, intended as general averages, and some degree of departure from them, both upward and downward, is to be expected locally.

Nearly all recent estimates place the temperature in the outer part of the mantle above the melting point of basaltic lava under surface conditions. Yet seismological evidence appears to indicate unequivocally that the earth is essentially solid down to the boundary of the core. Old ideas of a thin, solid crust overlying a general zone of liquid rock have had to be abandoned. The general solidity of the mantle is, no doubt, the result of rise of melting temperature with increasing pressure. Verhoogen's (*1*) estimate of the increase of melting temperature of basalt at increasing depth within the earth is also shown in Fig. 1. It is noteworthy that at about 200 kilometers the melting-point curve very closely approaches the curves of estimated temperature. Presumably, however, since the mantle is largely solid, the temperature curves do not in general reach the melting curve. Nevertheless, it would appear that, locally, either a comparatively small rise in temperature or reduction of melting point through lowering of pressure or introduction of fluxes might result in melting and formation of magma.

None of the estimates (Fig. 1) bring the temperature at 40-kilometer depth close to even the surface melting point of basalt or the observed temperatures of eruption of Hawaiian lavas (1100° to 1200°C). It seems, therefore, that if our deductions on the depth of origin of Hawaiian magma are correct, its formation cannot be accounted for by simple release of pressure. A local rise in temperature appears to be demanded. Such a rise is not unlikely. All over the earth volcanic areas commonly have thermal gradients considerably higher than the general average. This indicates a local rise of the isogeotherms (surfaces of equal temperature within the earth) that may be not only the result but the cause of volcanism.

The problem of the origin of volcanic heat is closely tied up with that of origin of the heat of the earth as a whole. Verhoogen (*2*) has pointed out that the amount of heat brought to the earth's surface by volcanic action is only a small fraction of the heat being conducted to the earth's surface and radiated into space, and that therefore the amount of heat represented by volcanism is relatively minor. Though this is true, there still remains the problem of how heat becomes concentrated locally to produce volcanic activity. Is it brought up from deep in the mantle by convection currents? Is it in some way generated by friction? At present we really have no adequate answer.

The amount of energy liberated as heat during some eruptions is very large. Thus, during the 1952 eruption of Kilauea the heat given off was approximately 4.3×10^{16} calories (*3*). In that particular eruption energy was

released almost wholly in the form of heat, but in others, large amounts are liberated in explosion and in earthquakes. Yokoyama (*4*) estimates that the total energy released in volcanic eruptions ranges from about 10^{16} to 10^{25} ergs. Almost certainly most of this energy originated at depth and was transported upward by rising magma.

Nowdays the heat of the earth as a whole is generally regarded as resulting largely from compression of the original earth-forming materials and, to a lesser extent, from liberation of heat through radioactivity. The suggestion has been made repeatedly that volcanism is the result of a local greater-than-average concentration of radioactive material. However, field checks with Geiger counters on still-active hot lava flows and within the volcanic gas cloud during an eruption reveal no increase in radioactivity over the general background level. Locally, a minor amount of heating takes place at the earth's surface as a result of burning of volcanic gases, and formerly it was supposed that an important amount of heating took place in the magma as it approached the surface, by oxidation and interreaction of included gases and other exothermic reaction (*5*), such as that between iron oxide and steam. It now appears, however, that such heating is probably relatively unimportant (*6*). Liberation of latent heat of crystallization also helps maintain the temperature of a magma during late stages, but it is probably a minor factor even then, and can have no effect until the magma cools enough for crystallization to commence.

Most of the heat of a volcanic eruption must be brought up from depth with the rising magma. This conclusion is supported by the fact that the temperature of magma erupting at the surface is little if at all higher than the melting temperature of the rock even under surface conditions, let alone under the higher pressures existing at the depth of magma generation. Small amounts of heat resulting from exothermic reactions in the rising magma may help make up for the losses of heat by conduction and radiation and by cooling resulting from the expansion of included gas bubbles, but heat from this source must be very minor.

In whatever manner the local rise in temperature is brought about, there is no question that melting does occur and magmas are formed. The molten rock pours out at the surface for all to see. An additional problem arises, however, because the composition of the melts reaching the surface is very different from the composition generally attributed to the mantle material. By far the most abundant volcanic rock is basalt, and it appears probable that other volcanic rocks have been derived in large part through modification of basalt magma. Basalt itself varies somewhat in composition, and three principal intergradational varieties are now recognized (Table 1). Of these, by far

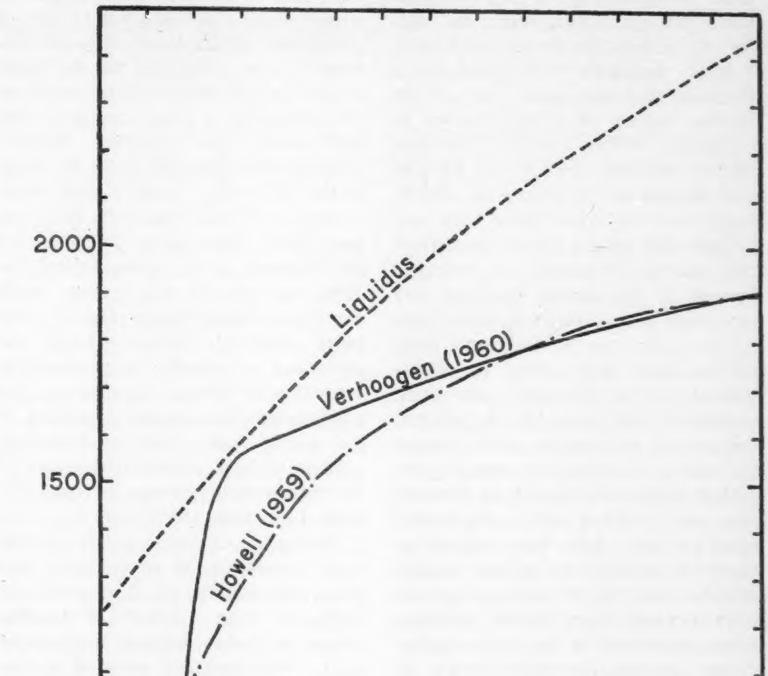

Fig. 1. Curves showing possible temperature distribution in the earth. The upper, dashed line, marked "Liquidus," indicates the approximate temperatures at which basalt would become completely molten, according to Verhoogen. [After J. Verhoogen and B. F. Howell, Jr.]

the most abundant is that known as tholeiitic basalt, which forms the major portion of the great Hawaiian volcanic mountains, with a volume approaching 100,000 cubic miles, as well as the huge accumulations of the Columbia River plain ($\approx$100,000 cubic miles), the Deccan region of India ($>$100,000 cubic miles), and other, similar masses. The other types of basalt may possibly arise independently of the tholeiitic basalt through melting within the mantle (*7*), or they may be derived from it.

Most geologists and geophysicists consider that the outer part of the mantle consists of a rock known as peridotite, which contains abundant olivine (peridot) and is rich in iron and magnesium. It should be remembered that we have never seen any samples that we are certain came from the mantle. Fragments of peridotite brought to the surface in rising lava have been considered to represent mantle rock (*8*), but the fragments show all gradations into gabbro (a coarse-grained rock of the same composition as basalt) and resemble, in mineral composition and texture, rocks formed by sinking of crystals in certain great gabbro masses that have been intruded into, and solidified within, the earth's crust and have later been exposed to view by erosion. It appears equally probable that the peridotite fragments were derived from similar intrusive masses transected by the rising magma.

The generally accepted theory of peridotite composition of the mantle is based on two general lines of evidence: the physical properties of the mantle material indicated by seismological and other geophysical evidence and the composition of stony meteorites. Whether the latter represent samples of the sort of material from which the earth was formed or fragments of a disrupted planet, it seems probable that they supply a clue to the composition of the earth's interior. Stony meteorites approximate peridotite in chemical composition (Table 1), and peridotite has the density and elastic properties demanded by geophysical data on the mantle. But if basalt magma originates from melting of peridotite, the melting is incomplete. Peridotite, like other rocks composed of several different minerals, does not have a single melting point but has, rather, a melting range of several hundred degrees. As the temperature rises into the melting range, the most easily melted constituents melt first, and if the liquid is then removed from the remaining solid it has a composition different from that of the total original solid. Basalt magma may be formed from peridotite in that way.

Another possibility is that the outer part of the mantle is not actually peridotite at all but, instead, is a high-pressure polymorph of basalt—a rock known as eclogite, which has the same chemical composition as basalt but is composed of different minerals and has a high density about equal to that of peridotite. At depths of 30 to 60 kilometers, such as we find for the upper surface of the mantle under much of the continents, a phase change of this sort seems quite possible. Beneath much of the oceans, however, the depth to the top of the mantle is only about 5 kilometers, and pressure is comparatively low. Nevertheless, Lovering (*9*) and Kennedy (*10*), among others, believe that even at this shallow depth the phase change takes place. If the outer mantle is indeed eclogite (or equivalent amphibolite or pyroxenite), formation of basaltic magma involves a total, rather than a partial, melting of the mantle rock. Such total melting appears to be a possibility because of the narrow melting range of basalt—in general less than 150°C (*11*).

Geological evidence points to the rapid generation, at many times and places throughout the history of the earth, of large volumes of basaltic magma of rather uniform composition (*12*). With only one principal exception, these are of tholeiitic composition, and even in that one area (the Thulean province of the northeast Atlantic Ocean) tholeiitic basalt is abundantly associated with the alkali basalt. In other areas, also, it appears that later lavas are alkali basalt, possibly derived from the tholeiitic magma by chemical processes (differentiation) in the magma chamber. The uniformity of the initial tholeiitic basalt is perhaps more readily accounted for by total melting of a rather uniform eclogite shell with the chemical composition of tholeiitic basalt than by partial melting of peridotite.

It is hoped that speculation on the composition of the outer part of the mantle will soon be eliminated by the evidence of actual samples taken from it in a deep hole (the "Mohole"), to be drilled through the crust and into the mantle somewhere on the deep sea floor. Establishment of the composition of the mantle will likewise serve to limit and direct petrologic speculation on the origin of basalt magma.

Subsurface Structure of Volcanoes

The structure of the upper few thousand feet within volcanic cones is fairly well known from the study of natural sections exposed in them by deep erosion. Below this, however, we again enter a region about which our knowledge is distinctly speculative.

The broadly rounded mountains known as shield volcanoes are built by numerous outpourings of fluid basaltic lava with very little accompanying explosive activity. These eruptions are fed principally by magma rising through cracks in the volcanic edifice, and the cracks are concentrated in certain zones, known as rift zones, that extend radially outward from the apex of the mountain. The eruptions are "fissure eruptions," characterized by lava spurting from a crack over a length of several hundreds or thousands of feet, or even several miles. On the great Hawaiian shield volcanoes, Kilauea and Mauna Loa, there is a rough alternation between eruptions at or near the summit of the mountain and those part way down the flank of the volcano, but all are fissure eruptions. The rift zones extend to the greatest depths exposed by erosion, about 4000 feet, and there consist of hundreds of closely spaced thin dikes, each dike a fissure filled with congealed magma. Presumably the rift zones extend on down beyond visible levels for several miles.

In contrast, the characteristic cones of continental volcanic regions, including such famous examples as Mt. Shasta in California, Mt. Mayon in the Philippines, and Fujisan in Japan, are built primarily by eruptions from a central pipelike conduit, which likewise extends downward as far as can be seen in areas exposed by erosion. Many dikes are present, and flank eruptions occasionally occur, but the dominant activity is eruption from the central vent. Explosive activity is more abundant, and indeed some volcanic cones are composed almost wholly of exploded (pyroclastic) material, though most of the large ones are composite cones composed of interbedded pyroclastic material and lava flows. The greater explosiveness of these volcanoes is partly the result of greater viscosity of the erupting magma, but it is commonly, if not always, also due to a greater amount of gas in the magma as it reaches the surface. Why these volcanoes have a central pipe conduit, instead of the fissure-type conduits of shield volcanoes, is not known, but this

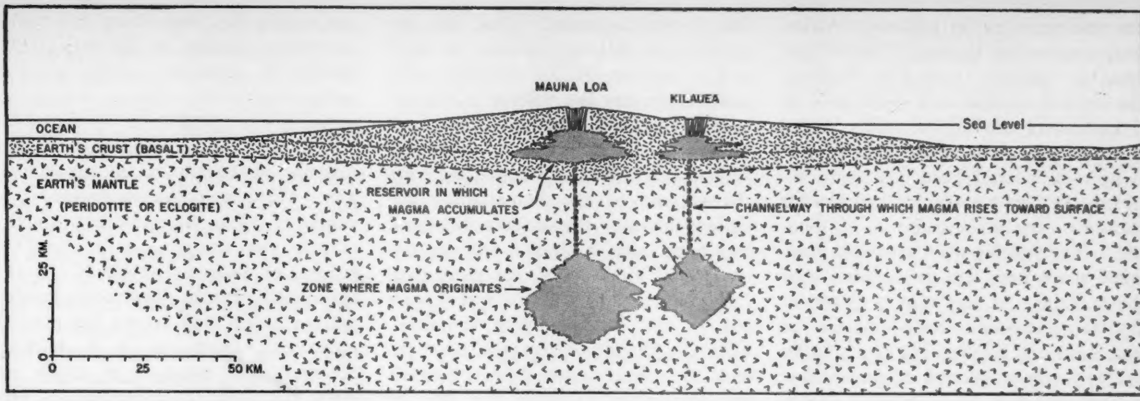

Fig. 2. Hypothetical cross section through Mauna Loa and Kilauea volcanoes, Hawaii, showing the area in which magma is believed to originate and the shallow chamber in which it is stored temporarily before it is erupted to the surface.

may well be the result of a fluxing action by the gas-rich top of the magma body and of coring out of the vent by outrushing gas during explosive eruptions.

Whether the surficial conduit is a fissure zone or a central pipe, it appears almost certain that many, perhaps all, major volcanoes are underlain at a comparatively shallow level by a chamber in which magma is stored temporarily before it is erupted to the surface. The evidence for such a chamber is the tumescence and detumescence of the volcanic mountain that commonly precede and accompany eruption—swelling and shrinking that may cause the mountaintop to move up and down several feet, and that seem explicable only by the inflation and deflation of an underlying chamber. True, the chamber may be far from simple and may be a plexus of compartments partly filled with hot, mushy, magmatic material rather than a well-defined inflatable bladder, but some sort of inflatable structure there must be.

The swelling and shrinking of the mountain is measured partly by ordinary surveying methods and partly by tiltmeters—instruments that measure the change in the angle of inclination of the volcano's side. Some tiltmeters are capable of measuring directly an angle as small as 0.01 second of arc.

Evidence for the depth of the magma chamber has been recognized at a few volcanoes. At Vesuvius, erupting lavas bring to the surface many fragments of dolomite of Triassic age, more or less altered by heat and volatiles from the magma, which are thought to be fragments from the roof of an enlarging magma chamber (*13*). The thickness of the sedimentary sequence in the region is well known, and the strata extend nearly horizontally beneath the volcano, making it possible to place the dolomite, and by implication the top of the magma chamber, approximately 6 kilometers below the general land surface. In western Scotland a quite different sort of evidence has been found. There, at volcanic centers of Tertiary age, thin intrusive sheets of igneous rock occupy upward-diverging conical fractures that appear to have resulted from upward thrust by an underlying magma body. Analysis of the attitudes of these cone sheets leads to the conclusion (*14*) that the tops of the magma bodies lay at depths of about 4 to 7 kilometers. Recent analysis of the pattern of tumescence and detumescence at Kilauea volcano has led J. P. Eaton to conclude that the inflatable chamber there lies at a depth of about 5 kilometers below the summit of the mountain—possibly even above the level of the surrounding ocean floor. In Japan, the changes in magnetism that accompany eruptions of Mihara volcano can be explained on the basis of temperature changes in a spherical mass (presumably a magma body) at a depth of 5 kilometers (*15*). The improbable shape of the magma chamber was assumed merely for the purpose of calculation.

Thus, at quite a few volcanoes, evidence suggests magma chambers at a depth of about 5 kilometers. On the other hand, Rittmann thinks the magma chamber at Ischia may be as shallow as 1 kilometer, and other areas of very closely spaced volcanic vents suggest a feeding chamber—possibly a broad sheet, or sill—of magma at very shallow depth. Locally, as in Tahiti (*16*) and in the West Maui Mountains of Hawaii (*17*), bodies (stocks) of coarse-grained igneous rock exposed by erosion indicate that sizable masses of magma worked their way to within 1 or 2 kilometers of the surface. However, these appear to be offshoots (cupolas) from the main reservoir, or even independent small reservoirs, rather than the main magma chamber itself.

Earthquake shear waves will not travel through liquids. In Kamchatka, the absence of shear waves of certain earthquakes that follow paths of transmission beneath the Klyuchevsky group of volcanoes has led Gorshkov (*18*) to believe that a magma-filled chamber lies at a depth of 50 to 60 kilometers, at the boundary between the earth's crust and mantle or within the outer part of the mantle. This finding may, however, be related to the seat of magma generation rather than to the shallow magma chamber that is responsible for the tumescence of the volcano.

Even less is known about the form of the magma chamber than about the depth. Daly (*19*) long ago suggested that the magma chamber beneath Kilauea might be a laccolith (a lens-shaped body of intrusive igneous rock that bends upward the layers of rock overlying it). It appears that this suggestion may have been a good one, though it was based not on any real evidence but on the intuition of an exceptionally capable geologist. Gorshkov (*18*), on seismological evidence, considers the magma chamber beneath the Klyuchevsky volcanoes to be a flat lens possibly 10 to 12 kilometers thick and with a diameter of the order of 30 kilometers. Only at one place, however, do I know of what may be direct evidence of the shape of the magma chamber that underlay a volcano. In

the Messum area, in southwest Africa, deep erosion has exposed a lens-shaped mass of intrusive rock that underlay the ancient volcano at a depth of 4 or 5 kilometers and almost surely served it as a feeding chamber (*20*). Underlying rock layers sagged downward beneath the body, which therefore is classed by the investigators as a "lopolith." The sagging may, however, have taken place very late in the history of the volcano. At any rate, a generally lenticular intrusive body capable of distention and contraction seems to be our best current picture of the shallow magma chamber. The concept is shown diagramatically, but to natural scale, in Figure 2.

Volcanic Engulfments

Calderas are simply unusually large volcanic craters. It appears, though this is not necessarily implicit in the term, that all calderas have been formed by insinking of the summit of a volcanic mountain as a result of removal of support from beneath. The formation of some calderas has been accompanied by the outpouring, on the flanks of the mountain, of large volumes of fluid lava. The birth of others is attended by the explosive ejection of great clouds of pyroclastic material, especially pumice, and huge avalanches of incandescent ash that rush down the mountainside. Volcano-tectonic depressions are still larger basins, also formed by collapse in volcanic regions. As in the case of the second type of caldera mentioned above, the formation of these depressions is accompanied by the eruption of voluminous flows of incandescent ash, commonly still so hot when they come to rest that the glassy fragments become welded together to produce dense rocks that resemble lava flows. The volume of the welded-ash flows (ignimbrites) in the rhyolite plateau of the North Island of New Zealand (the eruption of this plateau attended the subsidence of the basin of Lake Taupo), is about 2000 cubic miles (*21*).

It is a natural first conclusion that the removal of support that brought about the collapse was the result of the copious eruptions of lava or ash. Careful consideration of the volumes involved indicates, however, that this cannot be more than part of the answer. Commonly, if not always, the volume of the depression is much greater than that of the erupted material. Thus, the depression in Kilauea caldera in 1823 had a volume of 539,500,000 cubic meters, whereas the volume of the accompanying lava flow was only about 13,800,000 cubic meters. Similarly, Williams (*12*) has shown that, whereas the volume of the mountaintop engulfed to form the caldera occupied by Crater Lake, in Oregon, was approximately 17 cubic miles, not more than 7.5 cubic miles of material was thrown out in the accompanying eruptions. Material, presumably magma, must indeed have been removed from beneath the depressions to cause the lack of support, but much of it must simply have been shifted within the earth rather than erupted to the surface. Just where it went we do not know. The shiftings may be related to the much greater migrations of material that must take place within the earth during mountain building, isostatic adjustments to changes of surface load, and other up or down movements of large portions of the earth's surface.

Instead of the eruptions bringing about the collapse, it may to some degree be the other way around. The subterranean removal of material, producing the potential void that permits the collapse, may also bring about a marked reduction of pressure on magma rich in dissolved gases. The reduction in pressure may result in rapid separation of the gas and frothing of the magma, with expansion to several times its former volume, which brings about, in turn, explosive eruption of pumice and voluminous outpourings of pumiceous ash at the surface.

Volcanic Water and Other Gases

Water is the chief component of volcanic gases at the earth's surface, generally constituting more than 75 percent, by volume, of all gas collections at volcanic vents. Other common gases include carbon dioxide, carbon monoxide, sulfur dioxide, sulfur, sulfur trioxide, hydrogen sulfide, hydrochloric acid, and ammonium chloride, and in lesser abundance hydrogen, hydrogen fluoride, boric acid, methane, nitrogen, and argon. Not all of these gases are always present, and their relative abundance varies considerably, but water is nearly always predominant and often overwhelmingly so.

The amount of gas present in erupting magma has never been determined accurately, because of the physical difficulties in collecting suitable samples, and estimates vary widely. A limit can probably be placed on the possible amount by the solubility of gases in magma, as determined in the laboratory. Thus, at pressures prevailing at depths of 30 to 40 kilometers, granitic magma can contain up to about 10 percent of water by weight (*22*). The amount that can be dissolved in basaltic magma is less well known but may be about half as much. It is unlikely, however, that magmas at depth are often saturated. Many eruptions produce gas clouds of tremendous volume, and sometimes, as possibly in the 1906 eruption of Vesuvius, the gas may exceed in amount the liquid and solid material ejected. Generally, however, when the amount of gas is estimated carefully and recalculated in terms of percentage by weight, it represents only a very small proportion of the magma. Estimates during recent eruptions of Hawaiian volcanoes range around 1 percent by weight. Similar proportions of gas to lava have been estimated for recent eruptions of Nyamuragira volcano in central Africa, Hekla volcano in Iceland, and Paricutin volcano in Mexico. In spite of the generally small proportion, by weight, of gas to total erupted material, it is probable that throughout geologic ages all of the water on the earth's surface has been produced by volcanoes.

What is the origin of the water? It has been maintained by some volcanologists, notably by T. A. Jaggar, that it is formed, as such, only close to the surface, by the oxidation of deep-seated hydrogen. However, it is at least as likely that the hydrogen in volcanic gas collections is the result of the equilibrium reaction

$$H_2S + 2H_2O \rightleftharpoons SO_2 + 3H_2$$

which shifts toward the right at high temperature and low pressure (*4*). Most volcanologists regard the water as very largely derived from the mantle, along with the other constituents of the magma. There is theoretical reason to believe that all magmas contain at least a little water, even at depth, but this does not mean that all of the water given off by volcanoes originates at depth. Some water may be assimilated from fragments of sedimentary rock picked up by the ascending magma. Some may also be taken into the magma from ground water in surrounding

rocks. Though all surface water is probably ultimately of volcanic origin, much of the water released in any one volcanic eruption may have been recycled, even repeatedly. It is hoped that determination of the abundance of isotopes, especially of oxygen, may indicate how much volcanic water originates at depth and how much is of surface derivation.

One of the principal difficulties in the study of volcanic gases has been the reaction that takes place between the gases in the container after collection but before analysis. J. J. Naughton, of the University of Hawaii, is now developing a method by which the gases are separated by means of an absorption column in the field at the time of collection. It is hoped that this will make possible the determination of the actual composition and interrelationships of the gases at the time they arrive at the surface. From this determination, thermodynamic calculations will indicate something of the condition the gases, including water, must have been in under various earlier temperature-pressure relationships within the earth. Thus far, the results seem promising (*23*).

References and Notes

1. J. Verhoogen, *Am. Scientist* **48**, 134 (1960).
2. ———, *Phys. and Chem. Earth* 1, 17 (1956).
3. G. A. Macdonald, *Bull. volcanol.* **22**, 30 (1959).
4. I. Yokoyama, *Bull. Earthquake Research Inst. Tokyo Univ.* **35** (1955), 75 (1957).
5. T. A. Jaggar, *Volcano Letter Hawaii* **26**, 1 (1925).
6. A. J. Ellis, *Am. J. Sci.* **255**, 416 (1957); G. C. Kennedy, *ibid.* **246**, 529 (1948).
7. H. Kuno, *Bull. volcanol.* **20**, 37 (1959).
8. C. S. Ross, M. D. Foster, A. T. Myers, *Am. Mineralogist* **39**, 693 (1954).
9. J. F. Lovering, *Trans. Am. Geophys. Union* **39**, 947 (1958).
10. G. C. Kennedy, *Am. Scientist* **47**, 491 (1959).
11. H. S. Yoder, Jr., and C. E. Tilley, *Carnegie Inst. Wash. Yearbook* **56**, 156 (1957).
12. H. Williams, *Quart. J. Geol. Soc. London* **109**, 311 (1954).
13. A. Rittmann, *Vulkane und ihre Tätigkeit* (Enke, Stuttgart, Germany, 1936), p. 160.
14. J. E. Richey, *Scotland: The Tertiary Volcanic Districts* (His Majesty's Stationery Office, Edinburgh, 1935), p. 115.
15. T. Rikitake and I. Yokoyama, *J. Geophys. Research* **60**, 165 (1955).
16. H. Williams, *Bishop Museum Bull.* (1933), p. 105.
17. H. T. Stearns and G. A. Macdonald, *Hydrography Bull. Hawaii Div.* **7** (1942).
18. G. S. Gorshkov, *Rept. Acad. Sci. U.S.S.R. Geol. Ser.* **106**, 703 (1956).
19. R. A. Daly, *Proc. Am. Acad. Arts Sci* **47**, 47 (1911).
20. H. Korn and H. Martin, *Trans. Geol. Soc. S. Africa* **57**, 83 (1954).
21. R. L. Smith, *Bull. Geol. Soc. Am.* **71**, 795 (1960).
22. R. W. Goranson, *Am. J. Sci.* **22**, 481 (1931).
23. This article is Hawaii Institute of Geophysics Contribution No. 19.

High School Backgrounds of Science Doctorates

A survey reveals the influence of class size and region of origin, as well as ability, in Ph.D. production.

Lindsey R. Harmon

In the current resurgence of interest in the high school curriculum, major emphasis has been placed on the improvement of science teaching. An increasing concern has been felt for many years regarding the deficiencies of the high school courses of study pursued by most students, from the standpoint of preparation for possible pursuit of scientific studies in college and graduate school. The aim of the present article is to shed some light on this question through an examination of the high school backgrounds of a representative sample of recent science doctorates—specifically, the whole 1958 crop of doctorates from American universities.

This study was made possible by the existence of a file of third-level research degrees from all United States universities from 1936 to the present, maintained currently by the Office of Scientific Personnel of the National Academy of Sciences–National Research Council and supported by grants from the National Science Foundation and the U.S. Office of Education. This file includes doctorates in all fields; in the present study it will be useful to compare the findings on science doctorates with those on doctorate-holders in other fields. Currently, each candidate for a third-level degree fills out a simple one-page questionnaire as he approaches graduation; these completed questionnaires are collected by the deans of the graduate schools and forwarded to the Office of Scientific Personnel. One item on this questionnaire is the name and address of the high school from which the new doctorate-holder graduated. These high school addresses made the present study possible.

The initial use of these high school names was that made by Samuel Strauss, lately of the District of Columbia public school system, who had conducted a small-scale study on his own of the doctorate-level graduates of two nearby universities. He had had a good response from the high schools and sought a wider sample, based on the the Doctorate Records file of the Office of Scientific Personnel. His request for funds from the National Institutes of Health was supported by the Office of Scientific Personnel and backed up by a parallel request to the National Science Foundation from that office itself. Both requests were granted. Strauss undertook a study of the 1957 graduates, and the Office of Scientific Personnel made a study of the 1958 graduates, along practically identical lines. This article is based on the 1958 results.

Last spring, a questionnaire form was prepared for each holder of a 1958 doctorate, to be mailed to his former high school. All forms for a given high school were assembled and sent, together with a letter, to the principal, informing him of the relative standing of his high school in the state and nation with respect to the number of graduates in the 1958 doctorate "crop." For each of its graduates who held a

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Table 1. Fields of the doctorate compared in terms of mean intelligence test score, rank in graduating class, and grade point average.

Field of doctorate	Intelligence test score*		"Normalized rank" scores†		Math.-sci. GPA	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Mathematics	138.2	17.0	130.2	14.1	82.55	9.71
Physics	140.3	16.4	131.4	16.7	82.20	10.74
Chemistry	131.5	16.3	125.8	16.8	78.15	12.68
Geology	133.1	14.7	120.4	16.7	73.10	14.82
Engineering	134.8	16.2	128.0	17.3	80.65	11.74
All physical sciences	134.7	16.6	127.4	16.9	79.55	12.41
Biological sciences	126.1	16.4	117.3	18.1	69.35	15.55
Social sciences	132.0	16.9	120.1	18.8	67.70	17.36
Arts and humanities	132.1	16.4	122.6	18.1	70.25	16.90
Education	123.3	16.2	115.9	17.9	66.35	16.32
Social sciences, arts, education	129.8	17.1	119.6	18.5	67.95	16.97
Natural sciences	131.7	17.0	123.9	18.0	75.80	14.46
Total	130.8	17.1	121.8	18.3	71.55	16.37

*Intelligence test scores converted to Army Standard Scale values, with a mean of 100 and standard deviation of 20. †Rank in class converted to Army Standard Scale (see text).

1958 doctorate, the school was given information on all degrees held and was asked to supply information from the school records, to be kept confidential and used for research purposes only.

The rate of response to this questionnaire by the high schools was most gratifying, particularly as it indicates that any bias in the results due to nonresponse is small indeed. In 1958 there were 8930 doctoral degrees awarded. Of this total, approximately 13.3 percent went to people who had graduated from foreign high schools. That leaves 7787 from U.S. high schools. We were able to identify the high schools of 7063 of these, or about 91 percent. For a variety of reasons, high school information was not available on the remaining 9 percent (some had gotten high school diplomas via General Educational Development tests). Of this 7063 for whom we established tentative high school identification, we received from the high schools replies for 6455, or 91.4 percent—an astonishingly high response rate, particularly in view of the fact that no follow-up was attempted for the nonresponders. The usable data were reduced somewhat, to 6259, because some schools which did reply could provide no information (the school had burned down, records had been discarded, and so on), or because their returns were received too late for processing. Of the 6259 usable responses, there were 2853 in the fields of science: 1797 in the physical sciences and 1056 in the biological sciences.

From these high school data we are able to derive two measures of general academic ability and one measure of scientific achievement, as well as specific grades in various courses. From the intelligence tests in the records we are able to get a measure of general academic aptitude, and from the rank in graduating class, a measure of general achievement in all high school subjects. This high school class rank is, of course, also useful as a measure of aptitude for further work in college. Each of these measures requires a word of explanation, as each must be converted for statistical handling and interpretation.

Intelligence Test Scores

In the case of test scores, an attempt was made to compensate for inequalities in the spread of the I.Q.'s for various tests. The known variances of these tests were employed to set up a standard score scale; where the variances were not known (this was true in the case of some of the less-used tests), the assumption was made that the I.Q.'s were comparable to those for the most-used tests—the Henmon-Nelson, Kuhlman-Anderson, and California Mental Maturity tests—which apparently have very similar means and variances of obtained I.Q.'s. The final, common scale employed for the standardized tests is necessarily an arbitrary one, to provide integrated results. For this scale we have adopted the Army Standard Scale, which assumes a mean score of 100 and a standard deviation of 20. This facilitates comparison of the results of the study under discussion with results of other studies where explicit statements are made regarding the mean and standard deviation of the test scores. It is the scale adopted by Wolfle in his *America's Resources of Specialized Talent* (Harper, New York, 1954). Comparison with the older Stanford Binet scale, which has a standard deviation of the I.Q. of about 16 or 17 (varying with age), gives the following results: a Binet I.Q. of 125 equals Army Standard Scale 130, and Binet 140 equals Army Standard Scale 158, rounded to the nearest whole number.

Rank in Graduating Class

High school class rank, in its original percentile form, is unsatisfactory for computational purposes because the centile rank is not a constant unit of measurement. Hence, we have transmuted these centiles to standard scores, assuming a normal distribution of class ranks, and have termed them "normalized rank scores." This scale has a mean of 100 and standard deviation of 20, to match as nearly as possible the interpretative significance of the intelligence test scores. However, a one-for-one comparison is not justifiable, as these normalized rank scores are of course based on high school graduates only, whereas the intelligence scores are based on the whole population. Because of selection on the basis of academic ability throughout the school years, high school graduates are of course superior to the general population, and the standard provided by this norm group is distinctly more rigorous than that provided by the intelligence tests.

It is well to remember, however, in interpreting these normalized high school rank scores, that if one seeks to compare any two individuals, he makes the assumption that the high schools from which the two students came are equal in their academic standards. Taking all schools together, we know that this is not the case, of course. The norms are local only. This deviation from the standardized test scores is significant for our purposes, particularly when we make comparisons between schools of different sizes and different regions. Whatever educational handicaps a student may suffer by coming from an inferior educational environment is compensated for in the class rank score—he is compared with his peers in this score, and not with all students across the nation. Further, in field-to-field comparisons these interschool differences tend to cancel out, so that the normalized high school rank may be considered to be unbiased

by differences in schools when we compare one field with another. Individuals from schools of all levels of excellence are found in all doctorate fields.

Mathematics-Science Grade Point Average

These two indices provide two measures of general academic ability at the high school level. For a study of scientists-in-the-making we are interested in particular in a third measure, based specifically on the grades in mathematics and science earned in high school. Accordingly, there was computed for each student a mathematics-science grade point average (GPA) in which a grade of C is equal to 50, a grade of B is equal to 70, and a grade of A is equal to 90. While not directly comparable to the intelligence or high school rank scales, this grade point average did yield a score readily handled statistically.

The data from all of these measures are perhaps best appreciated if seen graphically. Figure 1 provides a graph of the intelligence test scores of the doctorate population as a whole in comparison with the spread of scores for the general population of the country, as calibrated by the Army General Classification Test, or AGCT scale. The smooth dotted curve depicts the spread of scores found in a standard cross section of the whole population, while the solid polygon represents the distribution of the doctorate population. The two groups are, of course, not equal in size but are here depicted proportionally. A single year's section of the U.S. general population of the approximate age of the average 1958 Ph.D. includes 2.4 million people, while the d torate group from U.S. high schools numbers only 7787. Accordingly, the scale of comparison of the two groups is 3100:1, as only one person in 3100 attains the doctorate. The frequency scale for the general population is shown at left in Fig. 1. The doctorate population distribution scale adjoins it, giving the actual number of Ph.D.'s found at each 10-unit level of the Army General Classification Test scale. On the right in Fig. 1 is another kind of scale, showing the relative proportion of Ph.D.'s in the population at each level of ability. The curve at the far right utilizes this scale to express the proportion of doctorates at each intelligence level. At the level of average intelligence (AGCT 100), the figure is practically zero. To the right, the curve rises to about 12 per 1000 at AGCT 130, which is just about the average ability level for all Ph.D.'s. From here on the curve rises more steeply, to about 60 per 1000 at the cut-off point that Terman used in his original studies of "genius" (AGCT 158), and to about 190 per thousand at the highest level tabulated, AGCT 175. Thus, even at the highest ability level, only one person in five attains the doctoral degree. There is thus a substantial reservoir of underdeveloped ability, regardless of the level of ability one assumes to be requisite for Ph.D.-level training, and even when we grant that not everybody at the highest ability levels needs a doctorate to complete his education.

Rank, by Doctoral Field

Table 1 shows the means and standard deviations for the several fields of the physical sciences, and for other groups, on the intelligence measures, normalized rank-in-class scores, and mathematics-science grade point average, all derived from the high school records. The leading position of the physical science group is apparent on all three of these indices. It is of interest to note that the arts and humanities group ranks second on all

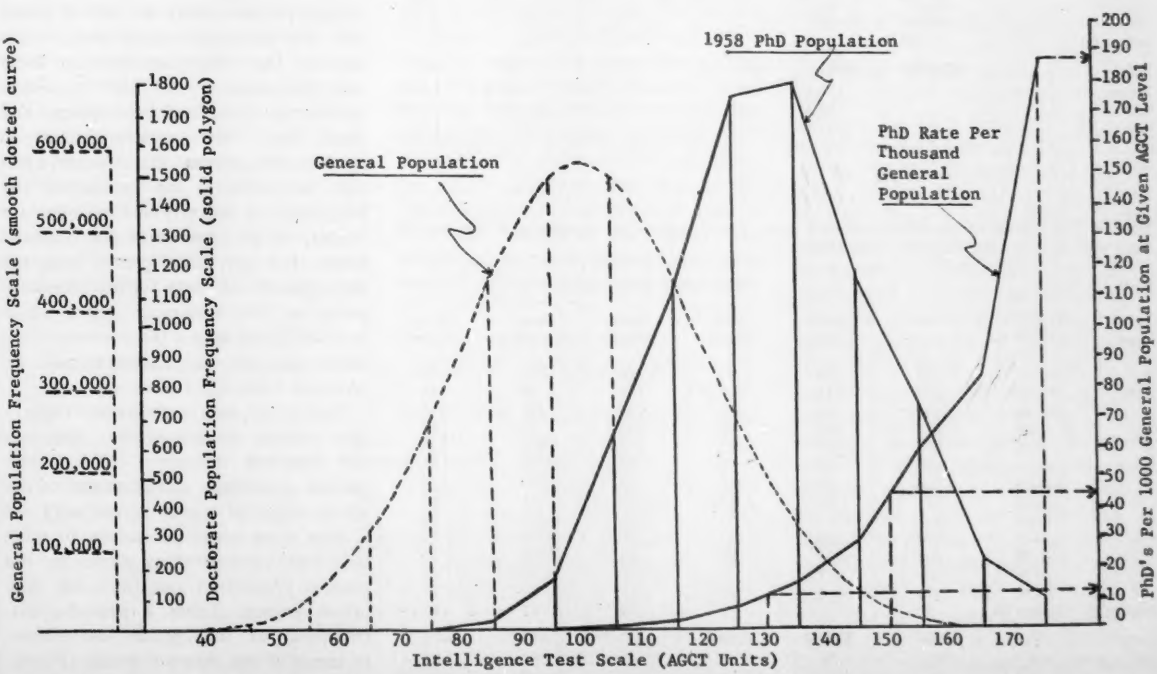

Fig. 1. Distribution of general intelligence test scores from high school records of 1958 doctorate population as compared with distribution of scores for the general population (scores are expressed in terms of Army General Classification Test units).

Table 2. Distribution of intelligence test scores for five general fields of the doctorate and for the total doctorate population.

Army Standard Scale dist.*	Approx. gen. population age 32, 1958†	Doctorates (*N*)					
		All fields	Phys. sciences	Biol. sciences	Social sciences	Arts, human.	Edu-cation
170 and up	530	46	20	1	15	7	3
160–169	2,670	101	46	11	27	14	3
150–159	12,150	337	153	37	93	35	19
140–149	39,250	530	246	67	112	74	31
130–139	108,000	826	298	150	179	116	83
120–129	218,200	806	243	153	214	89	107
110–119	361,800	520	140	119	106	65	90
100–109	457,400	298	64	79	67	28	60
90–99	457,400	81	19	19	12	8	23
80–89	361,800	15	3	4	2		6
70–79	218,200	7	1	5		1	
Below 70	162,600						
Total	2,400,000	3567	1233	645	827	437	425
100 (mean)		130.8	134.7	126.1	132.3	132.1	123.3
No inform.‡		4220	931	676	924	771	918

*The Army Standard Scale has a mean of 100 and standard deviation of 20. †Approximate mean age at attainment of the doctorate is 32; the number of individuals of age 32 is therefore the base population from which these doctorate holders were drawn. ‡U.S. high school graduates for whom no intelligence test scores could be obtained.

Table 3. Distribution of converted rank-in-class scores for doctorates in five general fields and the total doctorate population.

Normalized rank score categories	1944 High school grad. population	Doctorates (*N*)					
		All fields	Phys. sciences	Biol. sciences	Social sciences	Arts, human.	Edu-cation
160–169	1,377	55	27	4	13	8	3
150–159	4,947	195	100	19	40	25	11
140–149	16,881	547	244	70	106	87	40
130–139	44,931	819	325	120	170	115	89
120–129	93,687	1132	391	171	231	180	159
110–119	152,898	820	230	166	178	106	140
100–109	195,279	697	155	158	177	87	120
90–99	195,279	387	65	92	104	49	77
80–89	152,898	139	18	35	36	21	29
70–79	93,687	53	5	12	12	7	17
60–69	44,931	19	2	5	5	2	5
Below 60	23,205						
Total	1,020,000	4863	1562	852	1072	687	690
Mean		120.8	126.4	116.3	119.1	121.6	114.9
S.D.		18.3	16.9	18.1	18.8	18.1	17.9
No inform.		2924	602	469	679	521	653

Table 4. Distribution of mathematics-science grade point averages for doctorates in five general fields and for the total doctorate population.

Math.-sci. letter grade	GPA numerical grade	Doctorates (*N*)					
		All fields	Phys. sciences	Biol. sciences	Social sciences	Arts, humanities	Edu-cation
A	90	617	326	79	90	78	44
A−	85–89	837	414	106	135	98	84
	80–84	841	301	124	158	128	130
B+	75–79	625	204	96	138	95	92
B	70–74	665	153	122	155	109	126
B−	65–69	422	89	90	92	57	94
	60–64	508	84	110	122	73	119
C+	55–59	381	48	87	98	61	87
C	50–54	383	51	77	102	59	94
C−	45–49	230	26	43	77	30	54
	40–44	198	15	36	65	29	53
D+	35–39	109	7	21	31	21	29
D	30–34	70	4	15	21	13	17
D− or E	Below 30	52	1	3	23	12	13
Total		5938	1723	1009	1307	863	1036
No grades		321	74	47	69	56	75
Mean GPA		71.55	79.55	69.35	67.70	70.25	66.35
S.D.		16.37	12.41	15.55	17.36	16.90	16.32

three indices, surpassing the biological sciences even on the mathematics-science grade point average. The social sciences, with a rank almost identical to that of the arts and humanities on the intelligence index, clearly comes third in class rank and trails in fourth position on the grade point average. The pattern is quite clear—the social science group is composed of relatively bright individuals whose achievement in mathematics and science is distinctly out of line with their general high aptitudes. Whether this is a reflection of differential aptitude, or whether the relatively poor achievement in mathematics and science is important in determining these people's choice of field in college and graduate school cannot be ascertained from these data alone. Another feature of Table 1 that is quite striking is the marked difference in rank between the physical sciences and the biological sciences on all measures of ability; this difference is, in fact, somewhat greater for the indices based on local norms than for the intelligence tests which employ national norms. The trailing position of doctorates in education is apparent on all three measures. This group includes both Ph.D.'s in education and Ed.D.'s; the differences in findings for holders of these two degrees were very minor.

Within the physical science field, the subgroups that stand out on all measures are the mathematics and physics majors. The differences between these two groups are small, the physicists leading in measured intelligence and class rank, the mathematicians in mathematics-science grade point average. In Table 1, the means for the subgroups of the physical sciences are higher, on all three measures, than the means for any other group, with the exception of the mean for the chemistry group on the intelligence index, which is a half point below the corresponding means for the social sciences and the arts and humanities groups.

The group means shown in Table 1 give only a partial picture. Although the standard deviations enlarge this picture somewhat, consideration of the whole range of scores is necessary for a true comparison of scores in each field with corresponding scores for the general population and for other doctorate groups. Table 2 provides distributions of intelligence test scores, in terms of the Army General Classification Test, for the five major fields of the doctorate, for the doctorate group

Table 5. Number of doctorates per 1000 individuals in the general population, by field of specialization and ability level.

Intel. scale (AGCT units)	Doctorates (N) per 1000 general population						Non-Ph.D.'s per 1000 general population
	Phys. sciences	Biol. sciences	Social sciences	Arts, human.	Edu-cation	All fields	
170+	36.20	7.66	27.10	17.74	6.23	189.40	810.60
160–169						82.60	917.40
150–159	22.10	6.24	15.81	7.79	5.20	60.55	939.45
140–149	11.00	3.49	5.89	5.10	2.63	29.50	970.50
130–139	4.84	2.84	3.42	2.90	2.56	16.70	983.30
120–129	1.95	1.44	2.03	1.10	1.63	8.06	991.94
110–119	0.68	0.67	0.61	0.49	0.83	3.14	996.86
100–109	0.25	0.35	0.30	0.17	0.44	1.42	998.58
90–99	0.034	0.048	0.024	0.02	0.08	0.39	999.61
80–89						0.09	999.91
Below 80						0.07	999.93

as a whole, and for the general population. It shows, also, the number of individuals within each general field for whom these scores are available, and the number of individuals for whom no intelligence test data were available. Throughout the computations which follow, the assumption is made that data on distribution of intelligence test scores (and data on distribution of class ranks and grade point averages, also) are unbiased—that is, that the data are reported on a representative sample of the whole group. Although there is no way to check this assumption, by the same token there is no way to compute the degree or the direction of any bias that may exist. This assumption should nevertheless be borne in mind, for future developments might make it possible to define this situation more precisely, and perhaps might provide usable bias estimates.

The distributions of normalized rank-in-class scores are provided in Table 3, and the distributions of mathematics-science grade point averages, in Table 4. It may be noted that it is possible to provide a theoretical distribution of rank-in-class scores (but not of grade point averages) for the whole high school population simply by applying normal curve frequencies to the known total of high school graduates. The year 1944 was chosen as most representative for the 1958 doctorate group; actually, these people graduated from high school over a period of several years, the year of graduation being, on the average, most recent for the physical science group and earliest for the education group.

Correction for Inequalities

Because the various fields of specialization are unequal in "popularity" or in number of people entering them, it is necessary to make some corrections in the raw frequency distributions of Tables 2, 3, and 4 in order to obtain the most meaningful comparisons. This has been accomplished in the next set of tables through a series of corrective coefficients, to correct for differences by field in the proportion of individuals for whom data were provided by the high schools, to correct for relative field size, and then to express the results in terms of an index number which facilitates field-to-field and level-to-level comparisons. In Table 5, the number of doctorates at each intelligence level in each field is compared with the number of people in the general population at that intelligence level. The figures given in the table have been corrected for unreported scores, but differences in field size remain. The vertical comparisons—that is, comparisons between ability levels for any given field—are thus justified, but the interfield comparisons are subject to error. The column for all fields combined (column 7) reflects all ability levels, whereas breakdowns by field are not given for the extremes of the distributions because of the unreliability of the small numbers at these levels. The entries in this "all fields combined" column are plotted in Fig. 1, together with the frequency distributions of the general population and of Ph.D.'s. It should be noted, in studying the figures in column 7, that they are not the simple sum of the entries under the various field headings; this is because of variations in field size and in score distributions within each field. Column 8 shows the number of non-Ph.D.'s in the population at each ability level—in effect, the untapped reservoir at any level of intelligence.

Field-to-Field Comparisons

Table 6 provides indices which may be used to compare the fields with each other at each level—a procedure not justifiable in Table 5. For Table 6, the data for each field were first corrected for field size and then divided by the Ph.D.-attainment rate for all fields combined at AGCT level 130. For this index base, any productivity rate might have been chosen; the rate for people of "mean doctorate ability level" appears to be a useful reference point. To interpret the resulting figures, look at the first entry in column 2—1053 for physical sciences at AGCT level 160 and above. This means that this ability stratum of the population produced doctorates in physical science at a rate 10.53 higher than the productivity rate for doctorates in general of the ability stratum AGCT 130. In column 2 it may be seen that this same ability stratum produced biological scientists at only 3.65 times the base rate. In column 3, the figure 999 means that social scientists were produced by this highest-ability stratum at 10 times the base rate. The figure for doctorates from this stratum in the

Table 6. Doctorate productivity indices for the several fields and ability levels.*

Intel. scale (AGCT units)	Productivity index						
	Phys. sciences	Biol. sciences	Social sciences	Arts, human.	Edu-cation	All fields	
170+	1053	365	999	945	278	1531	811
160–169						668	
150–159	643	297	583	415	232	490	
140–149	320	166	217	272	117	239	
130–139	141	135	126	154	114	135	
120–129	57	69	75	59	73	65	
110–119	20	32	23	26	37	25	
100–109	7	17	11	9	19	12	
90–99	1	2	1	1	4	3	1.5
80–89						0.7	
Below 80						0.6	

*These indices give a means of comparing Ph.D. productivity at each ability level and in each field (corrected for field size) with Ph.D. productivity at AGCT 130 (mean, all fields combined).

arts and humanities is about 9½ times the base rate, and for doctorates in education, slightly under 3 times the base rate. The over-all productivity of this intelligence stratum, shown by the figure 811 in column 8, is over 8 times the base rate. The number of doctorates represented by this combined category is adequate to warrant a breakdown into productivity rates for AGCT levels 160 to 169 and for 170 and above. The resulting figures are shown in column 7 as 668 and 1531, respectively—the latter indicating a productivity rate for doctorates for the highest intelligence level of over 15 times the rate for AGCT 130.

Figure 2 shows graphically the data of Table 6. Here each field is represented by a distinctive pattern, and the combined data for all fields are shown as an open box surrounding the separate fields, forming a frame of reference for the various fields as well as providing a general index for comparison of intelligence levels. It is apparent from Fig. 2, as from Table 6, that the physical sciences and social sciences are the outstanding fields at the higher ability levels, followed closely by the arts and humanities, with the biological sciences and education lagging far behind at AGCT levels of 140 and up. Whatever the reasons for these differences, it is apparent that the fields of biology and education have not been able to attract their proportionate share of individuals of highest intelligence, as intelligence is judged from high school intelligence test scores. As the problems in these fields are certainly inherently as challenging as those in the physical sciences or social sciences, it might be inferred that there is a failure somewhere, probably at the high school level or even earlier, to present these challenges adequately to the bright young people who eventually attain doctoral degrees.

Table 7. Number of doctorates per 1000 high school graduates, by field of specialization and rank in high school class.

Normalized* high school rank scores	Percentile ranks included	Doctorates (N) per 1000 graduates: Phys. sciences	Biol. sciences	Social sciences	Arts, human.	Education	All fields	Non-Ph.D.'s per 1000 graduates
160 and up	99.85+	27.8	5.7	13.4	9.0	4.5	64.0	936.0
150–159	99.3–99.8						63.1	936.9
140–149	98–99.2	20.0	6.4	10.0	8.9	4.9	51.9	948.1
130–139	93–97	10.0	4.1	6.0	4.4	4.1	29.2	970.8
120–129	83–92	5.8	2.8	3.9	3.3	3.5	19.3	980.7
110–119	68–82	2.1	1.7	1.9	1.2	1.9	8.6	991.4
100–109	49–67	1.1	1.3	1.4	0.8	1.3	5.7	994.3
90–99	28–48	0.5	0.7	0.9	0.4	0.8	3.2	996.8
80–89	15–27						1.5	998.5
70–79	6–14	0.1	0.3	0.3	0.2	0.3	0.9	999.1
Below 70	Below 6						0.5	999.5

*Normalized rank gives a scale with a relatively constant unit of measurement, whereas percentile ranks are of varying value, as shown by the percentile ranges in column 2.

Table 8. Doctorate productivity indices for the several fields and for normalized rank in high school class*.

Normalized rank scores	Productivity index: Phys. sciences	Biol. sciences	Social sciences	Arts, human.	Education	All fields	
160 and up	633	211	385	374	158	405	402
150–159						400	
140–149	456	240	289	370	169	328	
130–139	228	154	174	184	141	185	
120–129	132	106	113	138	121	122	
110–119	47	63	53	50	66	54	
100–109	25	47	41	32	44	36	
90–99	10	27	25	18	28	20	
80–89						9	
70–79	3	10	8	7	11	6	7
Below 70						3	

*The index here is based on 100 for the productivity rate (all fields combined) at normalized rank 121.8, which is the average for all doctorates.

Table 9. Percentage frequency and cumulative frequency distributions of mathematics-science grade point average, by field of doctorate.

Math.-sci. GPA scale	Phys. sci. At GPA	Phys. sci. Below GPA	Biol. sci. At GPA	Biol. sci. Below GPA	Social sci. At GPA	Social sci. Below GPA	Arts, human. At GPA	Arts, human. Below GPA	Education At GPA	Education Below GPA	Total At GPA	Total Below GPA
90+	18.9	81.1	7.8	92.2	6.9	93.1	9.0	91.0	4.3	95.8	10.4	89.6
85–89	24.0	57.1	10.5	81.7	10.3	82.8	11.4	79.6	8.1	87.6	14.1	75.5
80–84	17.5	39.6	12.3	69.4	12.1	70.7	14.8	64.8	12.6	75.1	14.2	61.4
75–79	11.9	27.7	9.5	59.9	10.6	60.1	11.0	53.8	8.9	66.2	10.5	50.8
70–74	8.9	18.9	12.1	47.8	11.9	48.3	12.6	41.1	12.2	54.1	11.2	39.6
65–69	5.1	14.0	8.9	38.9	7.0	41.2	6.6	34.5	9.1	45.0	7.1	32.5
60–64	4.9	8.8	10.9	28.0	9.3	31.9	8.5	26.1	11.5	33.5	8.6	24.0
55–59	2.8	6.0	8.6	19.3	7.5	24.4	7.1	19.0	8.4	25.1	6.4	17.6
50–54	3.0	3.1	7.6	11.7	7.8	16.6	6.8	12.2	9.1	16.0	6.5	11.1
45–49	1.5	1.6	4.3	7.4	5.9	10.7	3.5	8.7	5.2	10.8	3.9	7.2
40–44	0.87	0.70	3.6	3.9	5.0	5.7	3.4	5.3	5.1	5.7	3.3	3.9
35–39	0.41	0.29	2.1	1.8	2.4	3.4	2.4	2.9	2.8	2.9	1.8	2.1
30–34	0.23	0.06	1.5	0.30	1.6	1.8	1.5	1.4	1.6	1.3	1.2	0.88
		0.06		0.30		1.8		1.4		1.3		0.88
10–14	0.06	0	0.30	0	1.8	0	1.4	0	1.3	0	0.88	0

High School Class Comparisons

Table 7 presents data for normalized rank-in-class corresponding to data in Table 5 for intelligence test scores—that is, number of doctorates per 1000. The base population here, however, is the total high school graduating class for 1944, not the general population. Table 8 presents data for normalized rank-in-class that correspond to the index figures for intelligence given in Table 6. The range of index figures is much more restricted for class rank than for intelligence test scores, the highest category for class rank out-producing the average by only 4:1, as compared with 8:1 for the top intelligence-test category. Apparently there are factors quite unrelated to later attainment of the doctorate that are more heavily involved in rank in high school class than they are in intelligence-test performance. This is particularly apparent in the social science field.

The data for mathematics-science grade point average do not lend themselves to a normative treatment in the way that intelligence-test scores and class ranks do, for we have no norm base from which to compute the performance of the nondoctorate popula-

tion. Table 9 gives the percentage for each field at each grade-point-average level, and the cumulative frequencies by field. The letter-grade equivalents for each numerical grade point average are given in Table 10 for convenience in interpreting the data. In Table 9, the first column within each field gives the percentage of all cases within the field at each given grade-point-average level. The second column for each field gives the cumulative percentages from the bottom, or the percentile rank with respect to the lowest score, in each grade-point-average category. To take the highest category, 90+ or "straight A," it may be seen that 18.9 percent of the physical science group score a straight A in high school math and science courses. Another 24 percent fall just barely short of a straight A, so that only 57 percent in this first field fall below the A− category. By comparison, about 82 percent of the biological scientists, 83 percent of the social scientists, 80 percent of the arts and humanities group, and 88 percent of the education group fall below this point. Similar comparisons may be made at each grade-point-average level.

To obtain a somewhat different view of the same data, the doctorate-holders achieving each specified grade-point-average level were divided by field, and the percentages assigned to the respective fields are tabulated in Table 10. Thus we see that of all doctorate-holders achieving straight A in high school math and science, almost 53 percent majored in physical sciences, 13 percent majored in biological sciences, 15 percent in social sciences, 13 percent in arts and humanities, and 7 percent in education (each entry is rounded to the nearest whole number). At the grade B level, the fields are more nearly equal, while at C and lower levels the social sciences and education are most prominent. These results are of course quite consistent with the findings on mathematics-science grade point average and with the means for the various fields, presented in Table 1.

Geographic Region

Up to this point we have been concerned with ability measures derived from the individual's high school records. It is also possible to apply to the data for each individual the ranking of his high school on indices of geographic location, size of graduating class, and so on, obtained in a manner similar to that used for obtaining intelligence and class-rank measures. The normative

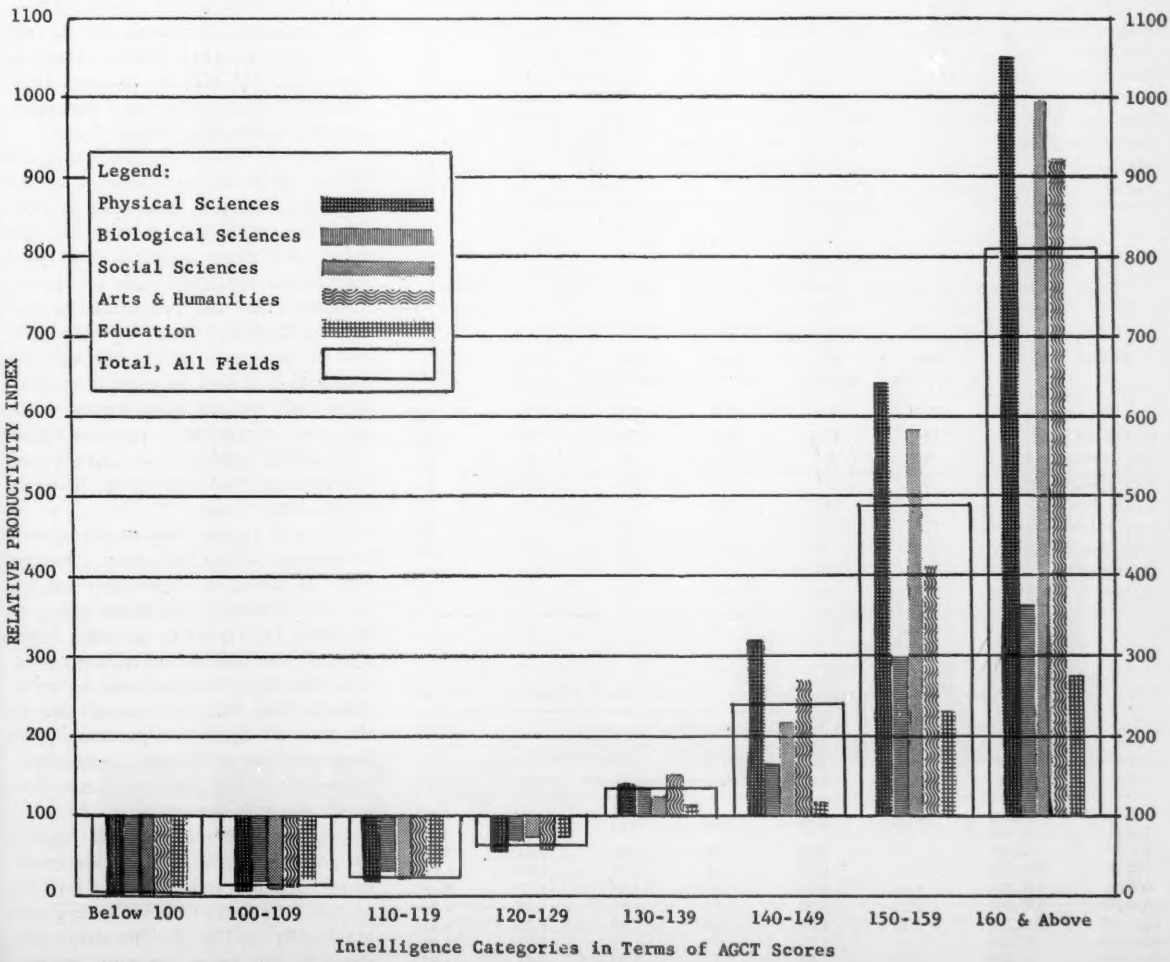

Fig. 2. Relative doctorate productivity, by field and by intelligence level.

Table 10. Relative concentration of the several fields of the doctorate for various mathematics-science grade point average.

GPA level	General field of doctorate: Phys. sciences (%)	Biol. sciences (%)	Social sciences (%)	Arts, humanities (%)	Education (%)	Letter grade equivalent
90+	52.84	12.80	14.59	12.64	7.13	A
85–89	49.46	12.66	16.13	11.71	10.04	A–
80–84	35.79	14.74	18.79	15.22	15.46	
75–79	32.64	15.36	22.08	15.20	14.72	B+
70–74	23.01	18.35	23.30	16.39	18.95	B
65–69	21.09	21.33	21.80	13.51	22.27	B–
60–64	16.54	21.64	24.02	14.37	23.43	
55–59	12.60	22.83	25.72	16.00	22.83	C+
50–54	13.32	20.10	26.64	15.40	24.54	C
45–49	11.30	18.70	33.48	13.04	23.48	C–
40–44	7.58	18.18	32.82	14.65	26.77	
35 and below	5.19	16.88	32.47	19.91	21.21	

Table 11. Number of doctorates in the several fields per 1000 high school graduates, by region of the United States.

Region	High school graduates, 1944 (N)	General field of doctorate: Phys. sciences	Biol. sciences	Social sciences	Arts, human.	Education	All fields
New England	59,800	2.97	2.13	2.68	1.75	1.71	11.23
Middle Atlantic	198,175	3.50	1.58	2.77	1.57	1.71	11.11
East North Central	213,260	2.07	1.23	1.51	1.06	1.30	7.17
West North Central	116,685	1.75	1.09	1.65	1.18	1.74	7.43
South Atlantic	96,150	1.75	1.47	1.34	1.28	1.26	7.08
East South Central	99,425	0.60	0.41	0.56	0.53	0.74	2.84
West South Central	97,895	1.51	0.95	0.99	0.96	1.31	5.73
Mountain	40,600	2.01	2.03	1.42	1.11	1.59	8.17
Pacific	98,010	1.93	1.38	1.49	0.89	1.07	6.74

Table 12. Doctorate productivity indices for the nine regions of the United States.

Region	General field of doctorate: Phys. sciences	Biol. sciences	Social sciences	Arts, humanities	Education	All fields
New England	140	164	161	151	124	147
Middle Atlantic	164	122	165	136	124	146
East North Central	97	95	90	91	94	94
West North Central	83	85	99	102	126	97
South Atlantic	83	113	80	110	91	93
East South Central	28	32	34	46	53	37
West South Central	71	74	59	83	95	75
Mountain	94	156	85	96	115	107
Pacific	91	106	89	77	77	88

Table 13. Number of doctorates in the several fields per 1000 high school graduates, by class size.

Class size categories	High school graduates, 1944 (N)	General field of doctorate: Phys. sciences	Biol. sciences	Social sciences	Arts, humanities	Education	All fields
1–9	17,200	0.69	0.76	0.64	0.61	1.08	3.28
10–19	72,700						3.73
20–39	154,000	1.08	0.94	0.89	0.85	1.52	5.10
40–59	102,000	1.41	1.07	1.08	0.79	1.45	5.70
60–99	139,500	1.80	0.95	1.17	1.04	1.23	6.16
100–199	180,800	2.27	1.50	1.73	1.42	1.45	8.36
200–399	204,200	2.78	1.49	2.09	1.30	1.23	9.01
400–599	92,200	3.19	1.74	2.95	1.39	1.61	11.00
600–799	36,400	3.23	1.67	2.82	1.73	1.45	11.03
800+	21,000	7.30	3.32	6.00	2.76	2.23	22.18

data needed for this purpose were derived from the U.S. Office of Education's *Directory of Secondary Day Schools, 1951–52*, which gives for each high school in the country the number of students graduated in 1952. The geographic region is of course derived directly from the address. For the purposes of this article, the United States is divided into nine regions, as follows. (i) New England: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut; (ii) Middle Atlantic: New York, New Jersey, Pennsylvania; (iii) East North Central: Ohio, Indiana, Illinois, Michigan, Wisconsin; (iv) West North Central: Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas; (v) South Atlantic: Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida; (vi) East South Central: Kentucky, Tennessee, Alabama, Mississippi; (vii) West South Central: Arkansas, Louisiana, Oklahoma, Texas; (viii) Mountain: Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada; and (ix) Pacific: Washington, Oregon, California, Alaska, Hawaii.

The U.S. Office of Education's *Directory* gives the total number of students graduating in each state in 1952. Regional totals were derived by summing, and these regional totals were adjusted to the 1944 base on the assumption that the proportion of students graduating in each region in 1944 was the same as in 1952. Although this assumption cannot be directly checked (if it could be, the actual figures would be used), it provides a constant figure, 1.02 million graduates, as a base for all comparisons with the 1958 doctorate population.

For each region, the number of doctorates per 1000 high school graduates was computed, by fields and for the total of all fields. These figures are given in Table 11. To derive an index which compares both fields and regions equitably, these data were corrected for variations in field size and then divided by the over-all figure for productivity of doctorates per 1000 high school graduates—7787/1,020,000, or 7.63. This produces the indices shown in Table 12, which are analogous, for the regions, to indices given in Table 6 for intelligence measures and in Table 8 for rank in class. The data of Table 12 are shown graphically in Fig. 3. The detail provided by this graph has some interesting aspects which suggest, if they do not

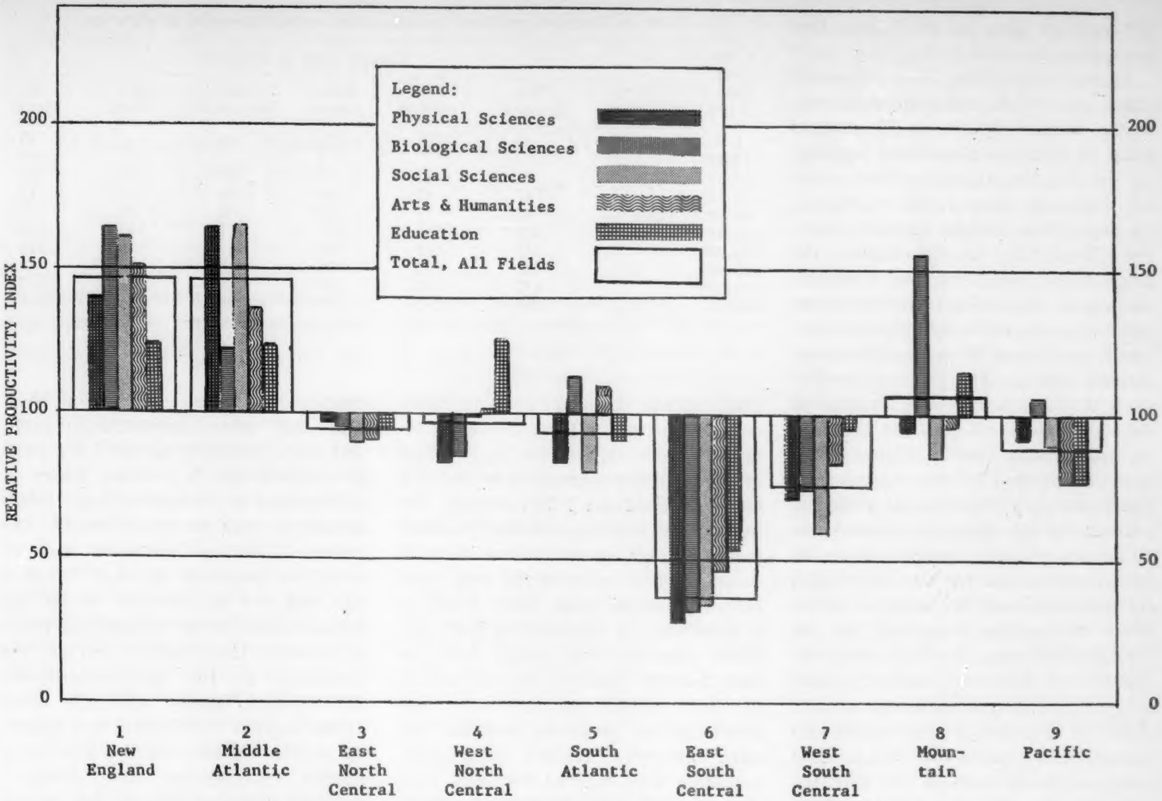

Fig. 3. Relative doctorate productivity, by field and by region of the United States.

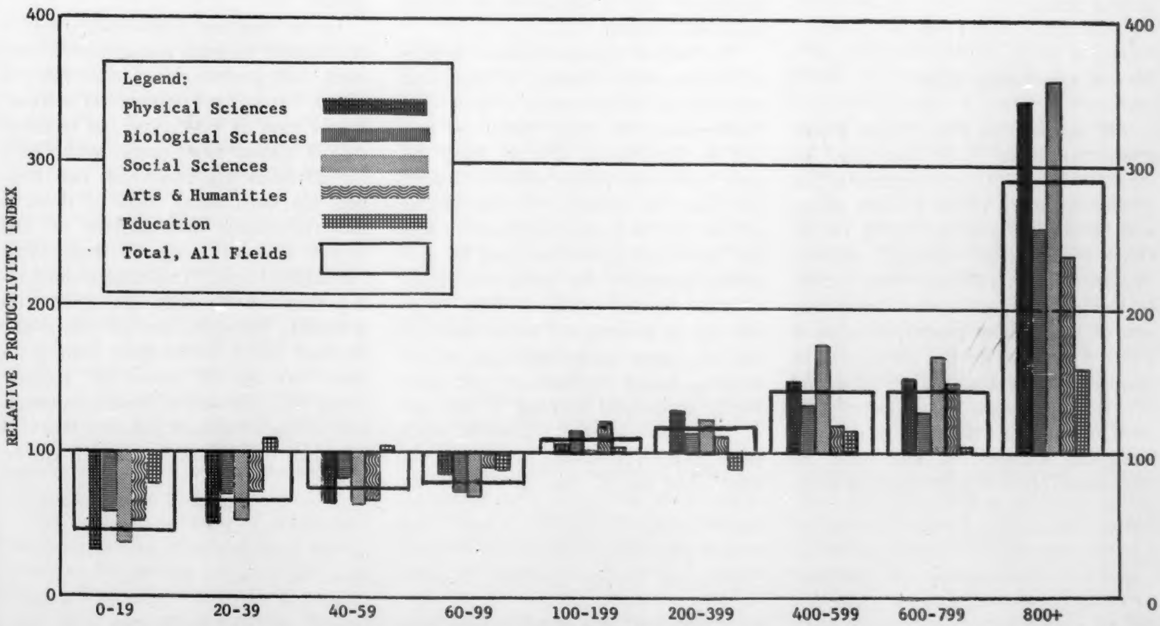

Fig. 4. Relative doctorate productivity, by size of high school graduating class.

demonstrate, some of the factors that determine choice of field.

It may be noted that the northeastern states, as a whole, outproduce the rest of the country by almost 50 percent, when all fields are considered together. In the Middle Atlantic states, where the dominant demographic feature is the huge urban complex extending from New York City to Philadelphia, the productivity index for the biological sciences is only 25 percent above the national norm, while for all fields combined, it is almost 50 percent above the national average. The obvious hypothesis is that this pattern is a function of the reduced contact with life forms in the urban areas. This hypothesis is further strengthened by the exceptionally high productivity index in the biological sciences for the Mountain states—over 50 percent above the national norm, although the indices for the other fields are unexceptional. In spite of these rather spectacular variations for the biological sciences, the field which deviates most from the norm is social sciences, with physical sciences in third place. In the case of these latter two groups, the deviations from the national norm are more often in line with the variations for all fields considered together and are thus not as conspicuous as deviations for the biological sciences. Education shows the least regional variation in productivity rate in the five general fields.

Table 14. Doctorate productivity indices, for various categories of class size.

<table>
<tr><th rowspan="2">Class size categories</th><th colspan="6">General field of doctorate</th></tr>
<tr><th>Phys. sciences</th><th>Biol. sciences</th><th>Social sciences</th><th>Arts, humanities</th><th>Education</th><th>All fields</th></tr>
<tr><td>1–9</td><td rowspan="2">32</td><td rowspan="2">59</td><td rowspan="2">38</td><td rowspan="2">53</td><td rowspan="2">78</td><td>43</td></tr>
<tr><td>10–19</td><td>49</td></tr>
<tr><td>20–39</td><td>51</td><td>72</td><td>53</td><td>74</td><td>110</td><td>67</td></tr>
<tr><td>40–59</td><td>67</td><td>83</td><td>65</td><td>68</td><td>105</td><td>75</td></tr>
<tr><td>60–99</td><td>85</td><td>73</td><td>70</td><td>90</td><td>89</td><td>81</td></tr>
<tr><td>100–199</td><td>107</td><td>116</td><td>103</td><td>122</td><td>105</td><td>110</td></tr>
<tr><td>200–399</td><td>131</td><td>115</td><td>125</td><td>112</td><td>89</td><td>118</td></tr>
<tr><td>400–599</td><td>151</td><td>135</td><td>176</td><td>120</td><td>116</td><td>144</td></tr>
<tr><td>600–799</td><td>153</td><td>129</td><td>169</td><td>150</td><td>105</td><td>145</td></tr>
<tr><td>800+</td><td>344</td><td>257</td><td>359</td><td>239</td><td>161</td><td>291</td></tr>
</table>

Size of Graduating Class

The influence of size of high school graduating class is of particular interest at this point, both because of the recommendations of the Conant report and because of a prior finding of the Office of Scientific Personnel, reported in *Science* [**130**, 1473 (27 Nov. 1959)]. In this prior report it was shown that size of high school graduating class is positively related to the *proportion* of graduates going into the physical and behavioral sciences, and negatively related to the proportion going into the biological sciences. At that time, no normative frame of reference was available; it was possible only to make comparisons within the doctorate population. From figures on high school graduating class size given in the U.S. Office of Education's *Directory of Secondary Day Schools*, referred to above, it was possible, in the present study, to determine how many of the total number of graduates came from classes of a given size, as tabulated in Table 13. These numbers were scaled down, as were those in Table 11, on the basis of the 1.02 million graduates of 1944. Then, by the processes described for other measures, relative productivity measures were derived for each class size for each field of doctorate. These indices are shown in Table 14 and displayed graphically in Fig. 4. Both the over-all trend, which shows a positive relationship, and the variation in these indices by field of doctorate are of considerable interest.

The field of physical sciences appears to be the most sensitive to class size, with the social sciences a close second. The reasons for these variations cannot be determined directly from the data, but some rather obvious hypotheses may be constructed. The smaller schools are, in general, deficient in both the laboratory equipment and the personnel necessary for extensive pursuit of the physical sciences. The larger schools, in general, are better equipped and offer more mathematics and science courses, taught by teachers with more highly specialized training. In the case of the social sciences, it seems much more likely (especially in view of the poor showing of this group on the mathematics-science grade point average) that urban concentration itself, with the multiplicity of social problems that it presents, is a strong factor in the decision of students in large urban schools to enter the social sciences. The biological sciences group, it may be noted, is positively affected by class size, but not so strongly as are the physical and social sciences. In order to examine this question further, the doctorates in the agriculture-related sciences were studied separately. Here a true negative relationship was found: the smaller classes produced more agricultural scientists per 1000 graduates than did the larger schools. The reason here seems quite obvious: these people come predominantly from farm backgrounds, and rural schools make up the bulk of the smaller-class-size categories.

In the arts and humanities group a relationship between size of high school class and production of doctorates is found, but it is not particularly marked. In the case of education, the relationship is almost nonexistent. When data for all fields are combined, two findings are outstanding. One of these is the remarkable productivity of the largest-class-size category—three times the national norm. The other is the finding that schools with less than 100 graduates per class are all below the national norm, while those with more than 100 are all above the national norm. This provides dramatic confirmation of the minimum standard that was proposed by Conant in his well-known study.

Science in the News

Religion and Aid to Education; The Peace Corps; Making Room for Educational and Public Service TV

Aside from the more direct issues, the Administration's education program will be affected by at least two incidental factors, of which one, civil rights, was reported on here two weeks ago. The other was brought plainly into focus last week when all five American cardinals met in Washington with a group of archbishops and bishops who make up the hierarchy's leaders in education and announced that they could not support, indeed would have to oppose, Kennedy's education program unless some provision were made for parochial schools. When the press asked for a White House reaction to the Catholic statement, Kennedy's news secretary, Pierre Salinger, announced that so far as the White House was concerned there was nothing to add to Kennedy's press conference remark of the day before, which was a flat assertion that aid for church schools would be "clearly unconstitutional," and therefore out of the question.

The entire business is a legislative nightmare. An aid-to-education bill passed the House last year, by a vote of 206 to 189, and the new Congress is generally reckoned to be at least a dozen votes more conservative than last year. An analysis by Congressional Quarterly, on the basis of how hold-over members voted last year and the known positions of new members, suggested that even a bill limited to classroom construction would be beaten 201 to 227 if the vote were held today and all members voted. A bill including money for teachers' salaries, as Kennedy's does, faces much tougher obstacles.

Yet, aside from the civil rights and parochial school issues, at least a construction bill would go through quite easily. Both these points of controversy took support away from the bill last year, and unless they grow decidedly worse this year, it is generally assumed, on the basis of his effectiveness to date, that Kennedy will be able to work up enough popular pressure to force a bill through the reluctant House despite the apparent 26-vote deficit. But whether he can have his way on teachers' salaries in the face of the additional opposition generated by the side issues is very doubtful, and both issues will give him other troubles on the rest of his program, devoted to aid for higher education.

The Catholic position is quite simple: Catholics feel morally obligated to maintain a parochial school system while they are legally obligated to help pay for the public school system as well. They recognize that there is not a great deal they can do about this double burden, which incidentally is quite a blessing in many areas to non-Catholics, whose taxes would have to be raised sharply if all the Catholic children decided to go to public schools. But if the Catholic community cannot eliminate the burden, they would at least like to keep it from getting a great deal worse by trying to see that if the federal government becomes heavily involved in education it includes at least a moderate amount of assistance for private as well as public schools, which of course would include assistance to parochial schools. Specifically, they would like to see the school bill, which will make grants to public schools, include in addition a program of low-interest, long-term loans to private schools.

Loans for Private Schools

The Catholic position is that they do not want grants, which would probably be unconstitutional in any case, but that a loan program would be both constitutional and just. The Administration faces a dilemma on this touchy question: its proposal includes a program of loans for all colleges, which includes Catholic and other church-sponsored colleges, and there is a wide feeling that ways will have to be found to make grants to private colleges as well. It is not only that the constitutional problems are awkward, but that like civil rights, the issue of aid to sectarian schools both divides the supporters of expanded federal aid to education and adds an emotion-laden argument to the position of those who oppose the education program anyway.

There is a fairly easy line to be drawn between aid to private schools, including sectarian schools, and aid to private colleges. One is generally considered a luxury available at their own expense to people who, for one reason or another, do not choose to send their children to public schools; the other is accepted as a basic element of the nation's facilities for higher education.

To change either of these views would mean a sharp break with traditional attitudes which have, over the years, taken on a legal force as they have become imbedded, tacitly at least, in the Supreme Court's interpretation of the religion clause in the First Amendment. The Constitution says only that "Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof." But for more than a century there has been no real dispute that the religion clause is to be interpreted very broadly. The catch phrase that a "wall of separation" between church and state has been decreed, as opposed to a mere line of separation, was coined by Thomas Jefferson.

But given this broad interpretation, the actual delineation as to just what would be constitutional in the way of assistance to private schools has been vaguely drawn, and cases involving assistance to private colleges have hardly ever reached the Supreme Court.

The most obvious effect of the tradition of keeping public funds from educational activities involving religion has been to discourage the tendency of religious groups to organize separate school systems, and so to limit the extent to which American children are brought up under a system that involves segregation by religion. Within the Administration and within the educational community there does not appear to be widespread concern about the difficulties in the way of finding approaches to provide adequate and equitable support for education without breaking the constitutional traditions.

What is worrying the Administration more is that the mere existence of this touchy area of controversy means that either meeting, or refusing to meet,

even the most reasonable claims of the sectarian schools and colleges adds a difficult complication for those who must concern themselves with the tactics of getting a program for education through the Congress.

A Role for Youth

The headquarters of the Peace Corps announced last week by Kennedy resembles nothing so much as his political campaign headquarters in the days after the Los Angeles convention. A major project, costing perhaps $50 million the first year, is being organized out of nothing in a period of a few weeks, and the disarray of the offices is not an entirely inaccurate reflection of the makeshift state of the program.

The Peace Corps is to be an organization of young Americans, primarily recent college graduates, who will serve two- or three-year tours of duty in underdeveloped countries, receiving no salary beyond an allowance kept small enough to discourage them from living beyond the normal standard of the country to which they are assigned.

It has not been made very clear yet just how they can make themselves most useful, nor just what sort of training will be necessary before they are sent overseas. The unconventional nature of the project itself, aside from the way it is being organized, practically overnight, is suggested by the fact that less than a year ago such an unconservative organization as Americans for Democratic Action refused to include the idea in its platform on the grounds that, although it sounded good, it really didn't seem very practical.

Despite all this, the response to Kennedy's announcement has been overwhelmingly favorable both at home and abroad, with the criticism coming almost exclusively from people who feel that the whole foreign aid program is a waste of money anyway. The Corps office was immediately flooded with 6000 letters from people volunteering to join, and Germany and Britain have begun to talk of forming their own Peace Corps, patterned after the American model.

The Corps hopes to have 500 to 1000 members overseas by the end of the year, working on such projects as literacy campaigns in English-speaking countries in Africa. Here at home the Corps administrators hope to organize programs in universities across the country to provide students interested in joining with specialized training in the language, politics, and culture of the countries to which they will be assigned.

But for the most part, the program is frankly an experiment, and no one pretends to know exactly how it will work out. It is not hard to find skeptics who suspect the whole thing will turn out to be a fiasco, but at the moment there is a good deal of optimism that it will develop into just what the Administration believes it will be: a convincing demonstration to the world that, as Kennedy insists, a new generation bursting with energy and new ideas has taken over the reins in America.

UHF, VHF, FCC

The Federal Communications Commission has decided to support a bill which would use federal power to regulate goods shipped in interstate commerce to compel manufacturers of television sets to make all sets capable of receiving the little used ultra-high-frequency channels, as well as the much used very-high-frequency channels. Something along these lines has been talked about for years, and if the bill goes through it should lead quite quickly to sharp increases in the variety of television fare that is available to the public, including a great expansion of educational and public service TV.

The current situation is this: For several years now there has been virtually no room for further assignments in the 12-channel VHF band. In contrast, several thousand additional stations could be accommodated in the almost deserted 70-channel UHF band.

There is a touch of madness in the situation: Sets capable of receiving both UHF and VHF cost 10 percent more than VHF only sets. So all-channel sets do not sell because there is hardly anything to see on UHF, and there is hardly anything to see on UHF because it is awfully uneconomical to run a UHF station when hardly anyone has a set that can receive the programs.

A few figures show how bleak the situation is. Of the 370 commercial stations which obtained UHF permits through 1959, only 167 ever went on the air. Ninety-two of these 167 have gone out of business, usually after heavy losses. And of the 75 stations still on the air only one-third are operating in the black.

The situation is even worse in educational TV. As of a few months ago, of 180 odd stations granted UHF permits, only 13 were on the air. In comparison, 35 of 88 authorized VHF educational stations were on the air, and most of those that were not on the air were located in small cities in the west. There was no educational station in either New York or Los Angeles, both of which have seven VHF commercial stations.

There is a general agreemeent that it is not a very sensible arrangement to have the nation's television service cramped into the inadequate VHF band, while the 70 channel UHF band goes virtually unused, but the FCC, which has been studying the situation since 1952, when it became apparent that UHF television was not developing as it should, has never been able to do much about it. The agency contented itself mainly with studying and re-studying the question to the point where a panel appointed by Congress to see what the FCC was doing came to the conclusion the FCC was just incapable of making decisions.

What efforts the FCC did make to solve the problem have not been very successful. It tried what it called "deintermixing," which meant that areas would be divided up so that some had only VHF channels, some only UHF. This never got off the ground because there always seemed to be some reason why any particular area should not be deintermixed.

The Commission then tried to get the Defense Department to trade off some of its frequencies adjoining the VHF band in exchange for some of the FCC's civilian frequencies. But the Defense Department, on technical grounds, refused to go along, and in any case this would only have provided about half a dozen extra channels, instead of the 70 available on UHF.

It is not clear whether the change in Administration had much to do with the FCC's finally going ahead with the present proposal, one of several that have been offered with the same general purpose of relieving all-channel receivers of their cost handicap in competing with VHF only receivers. But in any case, after several years of half-hearted efforts to deal with the problem there now seems to be real backing in the agency for expanding television service by the most direct route: that is, by breaking the curious circle of no UHF sets because no UHF stations and no UHF stations because no UHF sets.—H.M.

News Notes

Hearings on Radioisotopes and Radiation in the Life Sciences Scheduled by Subcommittee

Public hearings on "Applications of Radioisotopes and Radiation in the Life Sciences" are scheduled for 27–30 March, according to Congressman Melvin Price, chairman of the Subcommittee on Research and Development of the Joint Committee on Atomic Energy. All sessions will be held in room P-63, the Old Supreme Court Chamber in the Capitol Building. The hearings will focus mainly on applications of atomic energy in medical research and agriculture, with particular emphasis on studies of biochemical processes, immunization, genetics, and related research undertakings in which radioisotope techniques are utilized.

The objective of the hearings is to bring up to date testimony presented at the 1956 Joint Committee hearings entitled "Progress Report on Atomic Energy Research in Medicine, Biology, Agriculture and Food Preservation." The agenda for the coming sessions has been drawn up with the assistance of a steering committee made up of outstanding scientists. Witnesses have been selected with a view to securing as balanced a coverage of the field as possible.

The major implications of all of the testimony will be summed up by a six-man panel on the last day of the hearings. The panel members are J. Totter of the University of Georgia, S. Hendricks of the U.S. Department of Agriculture, G. Leroy of the University of Chicago, D. L. Ray of the National Science Foundation, H. Bentley Glass of Johns Hopkins University, and J. Bugher of the Puerto Rico Nuclear Center.

Witnesses

The tentative list of witnesses includes W. D. Armstrong of the Universary of Minnesota, Cornelius A. Tobias of the University of California (Berkeley), Robert J. Hasterlik of the Argonne Cancer Research Hospital, Seymour Shapiro of Brookhaven National Laboratory, S. R. Olsen and L. D. Christenson of the U.S. Department of Agriculture (Beltsville), Fred Andrews of Purdue University, H. L. Haller of the U.S. Department of Agriculture (Washington), Vaughan Bowen of the Woods Hole Oceanographic Institution, L. L. Thatcher of the U.S. Geological Survey (Washington), Allyn Seymour of the University of Washington, G. D. Novelli of Oak Ridge National Laboratory, F. J. Dixon of the University of Pittsburgh, H. J. Taylor of Columbia University, A. Benson of Pennsylvania State University, C. J. Borkowski of Oak Ridge National Laboratory, and J. Tyson of Austin High School, Austin, Tex.

Mayan City in British Honduras To Be Studied by Ontario Museum

The Royal Ontario Museum, Toronto, has announced that an expedition is now in British Honduras making preparations for a 5-year research project at one of the jungle cities of the ancient Mayas. Archeologist William Bullard, who was recently appointed field director of the expedition, will return to Toronto later this spring to make recommendations on the site to be excavated.

Bullard joined the Ontario Museum from Harvard University. For 3 years he was in charge of the Harvard expedition at Barton Ramie, a Mayan site in British Honduras.

The new Canadian propect is being financed by the Globe and Mail Publishing Company and a group of anonymous sponsors. The work is under the direction of the museum's department of ethnology. Digging will begin in a few months.

Mayan Rise and Fall Not Understood

The Mayan people, from about A.D. 300 to 900, were in the forefront of cultural progress in the New World, and much of their learning spread throughout Central America and beyond to other peoples. In an early period they developed a calendar which was superior to any in use elsewhere in the world, and their mathematical achievements were impressive—even greater than those of ancient Egypt.

The Mayas also built huge and magnificent cities, or ceremonial centers, with temples, courts, observatories, and academies, ruins of which now lie deep in jungle growth. Their pottery was often elaborately decorated, and the arts in general were well advanced.

The decline and eventual disruption of the Mayan society has often been blamed on the arrival of the Spaniards. However, the decline had already set in before the first Spaniards arrived, and its causes are still not well understood. It is hoped that the Royal Ontario Museum's expedition will help to clear up the mystery.

The ruins to be excavated are expected to be similar to such famous Mayan sites as Tikal, in Guatemala, and Copan, in (Spanish) Honduras. The project has the full cooperation of the British Honduras government.

Another Caribbean Expedition

This will be the second Royal Ontario Museum expedition this year to go to a British Commonwealth country in the Caribbean. Randolph Peterson, the museum's curator of mammals, is at present in British Guiana collecting bats, jaguars, monkeys, armadillos, and other mammals. The museum hopes that scientific projects such as these will help to strengthen ties between Canada and her Commonwealth neighbors.

News Briefs

Joint Committee chairmen. The Joint Committee on Atomic Energy has elected Representative Chet Holifield (D-Calif.) chairman and Senator John O. Pastore (D-R.I.) vice chairman for the 87th Congress. The Atomic Energy Act of 1954 provides that the chairmanship of the Joint Committee shall alternate between the Senate and the House of Representatives from one Congress to the next.

* * *

Kilauea volcano erupts. The Halemaumau fire pit in the center of Hawaii's Kilauea volcano began to erupt on 24 February. Lava rose as high as 150 feet. Kilauea is 4000 feet above sea level on the slopes of Mauna Loa in Hawaii National Park, on the southeast side of the island of Hawaii.

* * *

Eclipse photographed. An expedition from the Harvard College Observatory made a photographic recording in Italy of the 15 February total eclipse. Donald H. Menzel, director of the observatory, was in charge of the expedition, which included Gail Moreton, director of the Lockheed Solar Observatory in Burbank, Calif. Three coronal cameras were used to determine the structure of the inner corona, structure of the outer corona, and polarization of the corona.

The Harvard scientists accepted the invitation of M. Cimino, director of the Monte Mario Observatory at Rome, to

join the Italian party at Imperia, on the Italian Riviera. Astronomers from France and Sweden also came to Imperia. The Harvard program was supported by the Geophysics Research Directorate of the Air Force Cambridge Research Laboratories.

* * *

Hospital's 150th year. As part of the 150th anniversary celebration of the Massachusetts General Hospital, Boston, a symposium will be held on 7 April. Bernard Katz, professor of biophysics at University College, London, will speak on the transmission of excitation within cells and between cells, and Giuseppe Moruzzi, professor of physiology at the University of Pisa, will discuss problems in the physiology of sleep. The meeting, which is open to all, will be under the chairmanship of Stephen W. Kuffler of the Harvard Medical School.

* * *

Bacteriology society changes name. The Society of American Bacteriologists has changed its name after 61 years of existence. Effective immediately, the society will be known as the American Society for Microbiology. The new name is considered more descriptive of the broadened scope of the society's membership and interests. The American Society for Microbiology maintains its headquarters at 19875 Mack Ave., Detroit 36, Mich.

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Biology teaching materials. The AIBS Biological Sciences Curriculum Study has completed preliminary editions of 32 volumes of experimental materials for use in connection with biological education at the secondary school level. In large part, these volumes were prepared during the BSCS 1960 Summer Writing Conference at Boulder, Colo. While classroom use of most of these materials is currently restricted to the schools participating in the BSCS Testing Program, interested persons wishing to purchase individual copies of the materials can obtain further information from: *BSCS High School Biology*, Biological Sciences Curriculum Study, University of Colorado, Boulder, Colo.

* * *

Scientists and humanists. A national conference concerned with the communication of ideas between scientists and humanists will be held on 17 April at New York University. Participants also will explore means by which new and complex ideas can be communicated to the general community.

The conference, which has the theme "Toward a Community of Learning," is to be conducted by NYU's Division of General Education and Extension Services. Among the speakers will be Alan T. Waterman, director of the National Science Foundation; Clarence Faust, vice president of the Ford Foundation; and Perry Miller, professor of American literature at Harvard University.

Scientists in the News

The National Academy of Sciences has announced that its Jessie Stevenson Kovalenko Medal for outstanding contributions to medical science will be awarded this year to **Karl Friederich Meyer** in recognition of his achievements as an investigator, teacher, and administrator over half a century. Meyer, director emeritus and professor emeritus of the University of California's George Williams Hooper Foundation for Medical Research, will receive the medal at the annual meeting of the academy in Washington on 24 April.

Meyer's field of greatest interest has been the role of animals as hosts for vectors of human disease. He has made major contributions to the knowledge and control of psittacostis and plague. He is also credited with having developed a method to prevent botulism in the canning of foods, through proper bacteriologic precautions—a technological breakthrough for the canning industry. He also showed that mussels, during certain months of the year, are hosts to *Gonyaulax catenella*, a deadly protozoan associated with the destructive "red tides" off the Florida coast.

Karl Friederich Meyer

Australian scientific visitors to the United States and Canada include the following:

L. M. Clarebrough, Division of Tribophysics, Commonwealth Scientific and Industrial Research Organization (CSIRO), University of Melbourne, Victoria, 16 February–20 March. His itinerary includes Atomics International, Los Angeles; University of California, Berkeley; University of Illinois, Urbana; University of Chicago; Oak Ridge National Laboratory; University of Pennsylvania; I.B.M. Research Center, New York; G.E. Research Laboratories, Schenectady; National Research Council, Ottawa; Massachusetts Institute of Technology and Harvard University; and Brown University. After 3 months in Europe he will return to the United States to take part in the Gordon Research Conference, which is to be held in New Hampshire from 26 June to 1 July.

R. A. Duncan, Upper Atmosphere Section, CSIRO, Camden, New South Wales, 19 March. He has received an invitation from the High Altitude Observatory, University of Colorado, to join the scientific staff for a year.

D. L. H. Gibblings, Division of Electrotechnology, CSIRO, University Grounds, Chippendale, New South Wales, 7 March–9 April. His itinerary includes Palo Alto, Calif.; National Bureau of Standards in Boulder, Colo., and Washington, D.C. (12–17 March); G.E. Engineering Laboratories, Schenectady; Franklin Institute and the University of Pennsylvania; Harvard University; and National Research Council, Ottawa. He will also attend the I.R.E. convention in New York.

A. F. A. Harper, Division of Physics, CSIRO, University Grounds, Chippendale, 17 March–7 April. His itinerary includes the National Bureau of Standards in Washington, D.C. (20–24 March) and Boulder, Colorado; Symposium on Temperature, Columbus, Ohio (27–31 March); University of Virginia; California Institute of Technology; and University of California, Los Angeles.

J. R. Philip, Division of Plant Industry, CSIRO, Canberra, 15 February. He is serving for 2 months as a visiting professor at the University of Illinois, where he is working in porous-medium physics in the department of petroleum engineering.

T. McKnight, Department of Agriculture and Stock, Brisbane, 15 March. His 3-month itinerary includes the University of California, Berkeley; Wash-

ington State University; Texas A. and M. College; Oklahoma State University; Kansas State University; University of Minnesota, St. Paul; University of Wisconsin; and U.S. Department of Agriculture, Beltsville, Md.

Samuel M. Fox III, co-chief of the section on cardiodynamics of the National Heart Institute, has been appointed assistant director of the institute. He succeeds **Larry L. Terry**, now surgeon general designate of the Public Health Service.

In addition, **Richard H. Henschel**, assistant executive officer of the National Institutes of Health, has been named executive officer of the Heart Institute. He fills the vacancy left by **Robert H. Grant**, now assistant chief, Office of International Research Activities, NIH.

Bengt Borgstrom of the University of Lund, Sweden, will give the annual lecture of the G.I. Section of the American Physiological Society at 8 P.M. on 12 April at the Ambassador Hotel, Atlantic City. The title of his lecture will be "Intestinal Digestion and Absorption in the Human."

Ralph Bown, former Bell Telephone Laboratories scientist, and **Ernst A. Guillemin**, Webster professor of electrical engineering at Massachusetts Institute of Technology, are among those named by the Institute of Radio Engineers to receive I.R.E. awards in 1961. Presentation of the awards will take place at the 1961 I.R.E. international convention banquet on 22 March at the Waldorf-Astoria in New York.

Brown will receive the Founders Award "for outstanding service to the I.R.E. and for outstanding contributions to the radio engineering profession through wise and courageous leadership in the planning and administration of technical developments which have greatly increased the impact of electronics on the public welfare." This is one of the two highest I.R.E. awards and is bestowed only on special occasions.

Guillemin will receive the Medal of Honor, the highest annual technical award in the field of electronics, "for outstanding scientific and engineering achievements."

Six additional awards will be presented.

Leo Esaki, consultant at the I.B.M. Research Laboratory, Poughkeepsie, N.Y. (on leave from Sony Corporation, Japan) will receive the Morris N. Liebmann Memorial Prize "for important contributions to the theory and technology of solid state devices, particularly as embodied in the tunnel diode."

Eiichi Goto, University of Tokyo, Tokyo, Japan, will receive the Browder J. Thompson Memorial Prize for his paper entitled "The parametron, a digital computing element which utilizes parametric oscillation," which appeared in the August 1959 issue of the *Proceedings of the I.R.E.*

Helmut L. Brueckmann, U.S. Army Signal Research and Development Laboratories, Fort Monmouth, N.J., will receive the Harry Diamond Memorial Prize "for outstanding contributions to the theory and technology of antennas."

Manfred Clynes, Rockland State Hospital, Orangeburg, N.Y., will receive the W. R. G. Baker Prize for his paper entitled "Respiratory control of heart rate: Laws derived from analog computer simulation," which appeared in the January 1960 issue of *IRE Transactions on Medical Electronics.*

Peter C. Goldmark, CBS Laboratories, Stamford, Conn., will receive the Vladimir K. Zworykin Prize "for important contributions to the development and utilization of electronic television in military reconnaissance and in medical education."

Britton Chance, professor and director of the Johnson Research Foundation, University of Pennsylvania, will receive the first Professional Group on Bio-Medical Electronics Prize Award in Memory of William J. Morlock, "for the application of a variety of advanced electronic techniques in a long-term program of fundamental biological research."

At the forthcoming meeting of the Society for Investigative Dermatology, in New York, to be held 27–29 June, **René J. Dubos**, member and professor, Rockefeller Institute, New York, will deliver the first annual Herman Beerman Lecture. Dubos's topic will be "Molecules, Social Systems and Dermatology." The lecture will be given on 28 June at 2 P.M. in the Barbizon-Plaza Hotel.

Donald W. Taylor, professor of psychology at Yale University, will discuss "Psychological Studies of Thinking" as a Sigma Xi national lecturer at a number of colleges and universities during March and April.

In the same period, **Lloyd M. Beidler**, professor of physiology at Florida State University, Tallahassee, will also make a tour as a Sigma Xi national lecturer. He will discuss "Biophysical Approach to Taste."

Recent Deaths

Roland C. Davis, Bloomington, Ind.; professor of psychology at Indiana University and an authority on equipment design and techniques for electrophysiological recording of somatic responses; 23 Feb.

Frank S. Dolley, Los Angeles, Calif.; 76; a past president of the American Thoracic Surgery Association and a former professor of surgery at the Stanford University Medical School; had also taught at Columbia University, Yale University, and the University of Michigan; 25 Feb.

David G. Fables, Jr., Roselle, N.J.; 43; head of the biology department of Union Junior College, Cranford; a naturalist, he wrote a monthly column, "Afield in New Jersey," for 30 state newspapers; 22 Feb.

Elden B. Hartshorn, Lancaster, N.H.; professor emeritus of chemistry at Dartmouth College, who retired in 1954 after 41 years on the Dartmouth faculty; had served four terms as chairman of the chemistry department and had also been chairman of the division of sciences; 27 Feb.

Charles C. Norris, Philadelphia, Pa.; 84; professor emeritus of obstetrics and gynecology at the University of Pennsylvania Medical School; served as director of the department of obstetrics and gynecology from 1927 until his retirement in 1941; was the author of four well-known medical books; 26 Feb.

Leon E. Smith, Grainville, Ohio; 66; Henry Chisholm professor of physics at Denison University since 1928; 22 Jan.

John H. Stokes, Philadelphia, Pa.; 75; professor emeritus of cutaneous medicine and syphilology at the University of Pennsylvania's School of Medicine and Graduate School of Medicine; wrote a number of books on venereal diseases; 23 Feb.

William DeGarmo Turner, New York, N.Y.; 71; retired in 1946 as professor of chemical engineering at Columbia University; a technical director of Airkem, Inc., New York, makers of industrial deodorants; former professor and head of the department of the University of Missouri School of Mines; late Feb.

Book Reviews

The Purpose of American Politics. Hans J. Morgenthau. Knopf, New York, 1960. 368 pp. $4.50.

The purpose of American politics, says Hans Morgenthau, is "equality in freedom." This not very novel notion he examines in great detail and with an excess of subtlety and sophistication. The "present crisis of American politics," says Morgenthau, "is like its predecessors, essentially a crisis of the national purpose." Our times are out of joint not because our policies are bad but because "these policies have lost their organic connection with the innermost purposes of the nation." Although he does not say so, Morgenthau seems to imply that, in spite of frantic efforts to adapt our politics to the demands and conditions of contemporary civilization, we fail mainly "because we are no longer as sure as we used to be of what America stands for. . . ." This is the more surprising since the whole experience of America has been a quest for equality in freedom.

We continue to invoke the gods of *laissez faire* and an inbred hostility to political power at a time when both our domestic life and our central place in the society of nations demand the exercise of power if we are to achieve our historic purpose. A negativist posture toward political power was an inevitable consequence of the liberal or democratic struggle against a rigidly stratified society dominated by a hereditary elite. As Morgenthau observes, the "original purpose of democracy was the protection of the people from excessive and arbitrary power, not the exercise of governmental power itself." The triumph of majoritarian principles (however) has perverted the spirit of classical democracy by making public opinion not merely the source of governmental legitimacy but the "arbiter of policy with whose wishes the government must comply."

This new government by majority rather than government by consent of the majority has, according to Morgenthau, had a devastating effect upon the decision-making process. It has substituted the transient wishes of unstable numerical majorities for objective truth as the basis of public policy. It has impaired and placed in jeopardy those constitutional and moral safeguards designed to protect minority groups and the individual against the tyranny of the majority. And it has enfeebled and obscured both political power and responsibility by substituting an egalitarian for a hierarchal system of decision-making. The popular plebiscite, the committee system, and the public opinion poll have all but replaced the hierarchy of responsible legislative and executive officers in the determination of public policy. However legitimate the committee system may be in the legislative process, it is an abomination when it invades the executive branch, for the hallmark of government by committee is "that it shifts responsibility from an individual to a faceless collectivity."

Paradoxically, the triumph of majoritarian democracy leads not to majority rule as a stable and continuing source of power but to rule by organized minorities and to special interest groups exerting pressure upon both executive and legislative decision-makers. Even the major political parties through which conflicts over men and measures are theoretically resolved have become little more than electoral devices for conducting popularity contests among rival candidates without posing any significant issues of public policy. Pressure politics thus replaces party politics, and any meaningful responsibility for public policy is driven underground to be lost in a labyrinth of rival interest groups, committees, and influence peddlers. This functional fragmentation of power and responsibility is exacerbated, if not made possible, by institutional arrangements such as the constitutional separation of powers and the establishment of independent or quasi-independent administrative agencies.

The separation of powers, designed by the framers of the Constitution to impose restraints upon transient numerical majorities (a purpose which Morgenthau presumably would applaud), has in fact operated, he says, not so much to prevent the tyranny of popular majorities as to weaken the executive in his role of rational and responsible political leader. To compound the debilitating effects of the separation of powers, the disintegration of the executive power has been further advanced by the proliferation of administrative agencies over which the President has only formal control, if indeed he can be said to have even that. "The debility of the executive power caused by its inner fragmentation," says Morgenthau, "invites attack from the concentrations of private power, especially in the economic sphere." The result is a "new feudalism" which thwarts the majority will, as represented in Congress, even as it defies the executive leadership of the President.

State versus Private Power

Obviously a government so enfeebled by internal fragmentation and by external pressures from a thousand rival interests, and assailed by the divided and quixotic counsel of transient, ill-informed and fickle popular majorities, falls short of what America needs in a world of recurring, if not continuous, crises. What may have been adequate in an isolated pastoral society is no longer even tolerable, if the United States is to realize its underlying purpose of freedom in equality, not merely at home but in the world or at least in that part of the world not yet committed to a different purpose. "The cure," says Morgenthau, "is a state strong enough to hold its own against the concentrations of private power." For in the realization of our national purpose, the government must take the lead and a "government hemmed in by the feudalism of its bureaucracy and . . . the concentrations of private power and paralyzed by its fear of public opinion cannot lead. A people that fears public power more than private power, that values the private interest more than the public, and that judges the actions of government by what public opinion wants rather than by objective standards, cannot follow. The restoration of the national purpose then requires a reorientation of the national outlook, a change in our national style."

More specifically, we must restore the Presidency to its rightful place as

the source and center of national power and leadership. This can be done not by hemming him in with more and more assistants and managers but by cutting through the bureaucratic wilds to establish effective channels of communication and control leading to the White House. Yet even when this is done the President will need those qualities of greatness which enabled Washington and Jefferson, Jackson and Lincoln, Wilson and FDR to surmount other crises in other times.

Morgenthau has written cogently and eloquently about the most important problem of our time. There is much in his analysis to which I for one would take exception, and I find myself more in accord with his prescription than with his prognosis. The evil effects of the Separation of Powers, the alleged triumph of majoritarian democracy at the expense of individual and minority rights, the assumption that in America objective truth has been replaced by public opinion are but a few of Morgenthau's propositions which I believe to be overdrawn. But his statement of the central purpose of American politics is unexceptionable. Moreover his analysis of the relation of this purpose to vertical and horizontal mobility, social stratification, our unhappy venture as a colonial power, and our inescapable involvement in world politics is clear, subtle, and persuasive. It is a book to be read and pondered with care and meditation.

PETER H. ODEGARD
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Social Structure in Southeast Asia. *Viking Fund Publications in Anthropology*, No. 29. George P. Murdock, Ed. Quadrangle Books, Chicago, Ill.; Tavistock Publications, London, 1960. ix + 182 pp. $5.

This publication consists of a collection of ten analytic studies of the kinship and social organization of selected peoples of Southeast Asia. The papers were written by anthropologists for specialists in social structure and Southeast Asian studies, not for the curious reader looking only for general information or a brief overview of this critical area. Nine of the contributions are versions of papers presented in the Symposium on Social Structure in Southeast Asia at the Ninth Pacific Science Congress held in Bangkok, Thailand, during November 1957. The groups covered are a miscellany of so-called primitive tribes, peasants, and geographic segments of the large civilizations which make up this heterogeneous area. The papers are "The Mnong Gar of central Vietnam" (G. Condominas), "The Sagada Igorots of northern Luzon" (F. Eggan), "The eastern Subanun of Mindanao" (C. O. Frake), "The Iban of western Borneo" (J. D. Freeman), "The Javanese of south central Java" (R. M. Koentjaraningrat), "The Sinhalese of the dry zone of northern Ceylon" (E. R. Leach), "The aboriginal peoples of Formosa" (T. Mabuchi), "Supplementary notes on the Formosan aborigines" (Wei Hwei-Lin), and "The Magpie Miao of southern Szechuan" (Ruey Yih-Fu). Each is an important contribution to the anthropological coverage of Southeast Asia, which is still very spotty.

For an introduction to the volume the editor, George P. Murdock, who organized the symposium in Bangkok, has written a general theoretical statement "Cognatic forms of social organization." In this he first reviews all known types of kin groups in accordance with the system of classification he developed in his book *Social Structure* (Macmillan, New York, 1949); he then turns to the problem of bilateral or nonunilinear types which are common in Southeast Asia. Murdock draws upon his own vast knowledge of the social structure of peoples throughout the world and upon unpublished papers and discussions from a seminar on nonunilineal kinship systems held at the Center for Advanced Study in the Behavioral Sciences (Stanford University) in which he participated. A thorough discussion of the terminological and conceptual confusion which exists in this sector is followed by a proposed new classification system and a discussion of the principles of organization which define these types of groups.

Where previously all of these kinds of kin groups were more or less lumped into a single category and described by a variety of terms such as *ambilineal*, *utrolateral*, *multilinear*, and *ramage* in addition to *bilateral* and *nonunilinear*, Murdock distinguishes three types of kin groups which he calls *bilateral*, *ambilineal*, and *quasi-unilineal*. For the bilateral and ambilineal types he proposes the covering term of *cognatic* in order to contrast them with the more familiar unlineal types. The descriptive contributions of this volume are compared within this classificatory framework, as are a number of correlative features of social structure and kinship terminologies which seem to occur regularly with each type no matter where the types are found in the world.

As a symposium this volume is noteworthy in that the descriptive papers are of exceptionally high caliber and the introduction not only ties the papers together nicely but also goes beyond the scope of the presentations to make a contribution to the general theory of social structure.

WILLIAM DAVENPORT
Department of Anthropology, Yale University

The Nature of Animal Colours. H. Munro Fox and Gwynne Vevers. Macmillan, New York, 1960. xii + 246 pp. Illus. $6.50.

Not since 1953, when the other pigment-conscious Fox (Denis L.) brought out *Animal Biochromes*, has there been a convenient summing up of the causes of the hues we see in animals. In this new volume the authors provide a grand tour, conducted in a pleasantly readable style, and also a tantalizing invitation to do something about the pigments still awaiting investigation. A whole chapter is given over to laboratory experiments suitable for whetting the enthusiasm of students who might then go on to solve unknowns.

The table of contents may dismay the nonbiochemists, for the chapters are arranged to consider compounds in natural groups: melanin; sclerotin, ommochromes, Tyrian purple; carotenoids; hemoglobin, chlorocruorin; hemochromogens, porphyrins, bilins; hemocyanin, hemerythrin, hemovanadin; quinones; guanine, pterins, flavins; and a final miscellany. In none, however, will the nonbiochemist flounder in structural formulas. An appended chapter, "Synopsis of animal colours," clarifies the record by considering pigments by hue.

All through the book, the pages are sequined with esoteric bits of delightful information: fossilized melanin (150 million years old) used as ink in illustrating a scientific account of the extinct squids that made the pigment; colored sweat in human beings and red sweat in the hippopotamus; black rats turning gray one month after being given phenylthiocarbamide (the "PTC" of taste-test paper) in their food; the

yellow color of a wasp differing completely from the yellow color of a mimicking fly.

Even the unknowns include surprises: the pigments of red hair, whether on a girl or on a red squirrel, and of precious coral still elude identification; the green of a turtle's fat, or of a crayfish's green glands, remains an enigma. Some of the known data border on the unrealized for most readers: the myoglobin of red muscle, rather than the hemoglobin of blood, is the chief color at the butcher shop; the pink hue of boiled ham is due to a different pigment; the brown of overcooked beef is due to a third. The 17 handsome color plates will make readers eager to hunt down pigments in everything they see. A 612-entry list of references is a key to the pertinent literature.

LORUS J. MILNE
MARGERY MILNE
Durham, New Hampshire

Source Book in Astronomy, 1900–1950. Harlow Shapley, Ed. Harvard University Press, Cambridge, Mass., 1960. xv + 423 pp. Illus. $10.

The development of astronomy from 1900 to 1950 can only be described as explosive. During those years man threw away forever his heliocentric chains, "discovered" first the Milky Way galaxy, its size and distant center, and then "discovered" the universe. This was the era of the giant reflector and the initial development of the giant radio telescope, the giant electronic calculator, and the giant rocket. This was also the time when astronomy became astrophysics—when theoretical physicists such as Planck furnished the key to the nature of stellar radiation, Saha the key to the nature of a stellar atmosphere, and Einstein and Bethe the key to the fundamental question of what makes the stars shine.

This book is therefore quite different in character from its predecessor, *A Source Book in Astronomy* by Shapley and Howarth. In addition, however, because of the great technical complexity of some of the original papers, Shapley has wisely chosen on occasion to substitute review papers for the original sources. This makes for more enjoyable reading and for greater understandability. The 69 papers deal with instrumentation, the sun, the planets, stellar motions, spectra, variability, structure and evolution, spectrum-luminosity relationships, interstellar phenomena, galaxies, relativity and cosmogony, and surveys of astrophysical progress. As might be expected the greatest number of papers (15) are reprinted from the *Astrophysical Journal*; surprisingly enough, leaflets of the Astronomical Society of the Pacific are second in number (six). Astronomers will be grateful to Shapley for providing translations of out-of-the-way but historically important papers such as those of Hertzsprung on giants and dwarfs, Ambartsumian on expanding associations, and van de Hulst's original prediction of the 21-centimeter hydrogen line in radiation from cosmic objects.

This book bears the imprint of Shapley's personality in the well-written introductions to each of the 13 divisions and in the choice of papers. It is to be regretted that a place could not be found for such papers as those of Hubble on the distance of Messier 33 (the great breakthrough that dispelled all doubts about the nature of spiral galaxies), Trumpler on the amount of interstellar absorption, Stebbins and Whitford on the law of interstellar reddening, two or three more of the early radio astronomy discoveries, and the NRL rocket spectroscopy of the solar ultraviolet.

This *Source Book* is enthusiastically recommended to all students of astronomy.

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Goethe Link Observatory,
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Modern University Physics. James A. Richards, Francis Weston Sears, M. Russell Wehr, and Mark W. Zemansky. Addison-Wesley, Reading, Mass., 1960, xvii + 993 pp. Illus. $10.75

This new textbook is essentially a combination of the well-known *University Physics* by Sears and Zemansky and the recent *Physics of the Atom* by Wehr and Richards. According to the authors it represents an effort "to provide a meaningful introduction to classical, relativistic, and quantum physics." It assumes a concurrent course in calculus but no previous collegiate physics courses. Presumably, three 3-credit semesters or two 5-credit semesters are needed to cover the entire book; there are 45 chapters.

In combining two textbooks, duplication must be avoided and length kept to a reasonable number of pages. Some readers may therefore be disturbed to find that certain specialized topics have been omitted, although most of these topics will be taken up later in other courses. Fluid dynamics (including Bernoulli's theorem) and surface tension are not discussed, although Stokes' law is used in describing the Millikan oil-drop experiment. The chapter on impulse and momentum has been rewritten, and a short section on rockets has been added. This addition is timely, in view of the current interests of most students, but it is surprising that no mention is made of escape velocity. Also, Gauss' law is not stated in the section on electrostatics, nor are Kirchhoff's rules mentioned in connection with solving resistance network problems. The section on modern physics has no chapter on solid-state physics, although such a chapter is included in *Physics of the Atom.*

If the above comments appear to be adverse, such is not intended; the reader can see for himself that very little *basic* physics has been left out of this comprehensive treatment of general and (introductory) modern physics. The authors have tried to prune out material that was not essential to the basic aim of the text, and in this they appear to have succeeded. The continuity achieved is surprising for a book so ambitious in scope.

The order of topics is conventional: mechanics, wave motion, sound, heat, electricity and magnetism, optics, atomic physics, relativity, and nuclear physics. However, many of the shorter topics ordinarily classified as "modern" physics are interspersed throughout the first 36 chapters of the book—chapters nominally devoted to "classical" physics. Thus some modern theories and applications are discussed in conjunction with their classical counterparts. But this procedure is not applicable to all topics; hence, the last nine chapters of the book cover only recognized topics in modern physics.

On the whole, readers who like the approach of Sears-Zemansky and who want a one-volume textbook that includes ample modern physics for a comprehensive first course would do well to consider *Modern University Physics*; there appear to be, at present, no other single-volume texts which so nearly meet this need.

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Die philosophischen Grundlagen der Naturwissenschaften. Max Hartmann. Fischer, Stuttgart, 1959. 183 pp. DM. 19.

When Max Hartmann published the first edition of his *Allgemeine Biologie* (1927), he provided this penetrating introduction into the general problems and results of biology with a philosophical framework. *Allgemeine Biologie* begins with remarks on the position of biology in the system of the natural sciences, the methodology of the biological sciences, and the concept and range of general biology; it ends with sections on the body-mind problem, the epistemological foundations of biology, purposefulness, and the mechanism-vitalism issues. These pages were not those of a philosophizing specialist in science but of a philosophically trained thinker. Nor was this the first and only time that Hartmann had dealt with the relations between biology and philosophy. From 1924 to 1954 lectures and articles appeared in which this master of protozoology and cytology, and of the experimental and theoretical analysis of the general phenomena of sexuality and reproduction, bore witness to the philosophical foundations of biology.

Hartmann's *Die philosophischen Grundlagen der Naturwissenschaften*, a separate volume, appeared in 1948, and this second edition was published in 1959 when its author had reached his 82nd year of life. In its present form the book consists of two main parts, one dealing with the theory of the knowledge of nature, the other with the methodology of the natural sciences. A third section in the original edition dealt with epistemological and methodological and with controversial specialized problems of modern science, particularly physics and biology. It has been deleted in the new edition.

The first part of the book, nearly two-thirds of the volume, is a greatly abbreviated condensation of the *Grundzüge der Metaphysik der Erkenntnis* by Nicolai Hartmann, the late, contemporary namesake of Max Hartmann. It consists mainly of quotations from the former's work joined together by introductory and connecting passages. A complete unity is achieved in which Nicolai Hartmann's sharp formulations and Max Hartmann's explanatory or complementary phrases are fused together into a terse wholeness. The second part, that concerned with methodology, is, in a full sense, Max Hartmann's own. Here he discusses such topics as the elements of the so-called inductive method of science—namely analysis, synthesis, induction, and deduction—which together form a fourfold methodologic system of induction; distinguishes between generalizing and exact induction which correspond closely, but not completely, with the comparative and experimental methods; and illustrates these concepts with a number of examples taken from the history of the sciences. This part of the book is less demanding of the reader's concentration and philosophical training than the first, so that the author urgently recommends to his scientific audience that the second part be read before the first.

Hartmann rejects the positivistic point of view and at the same time goes beyond the limitations of the Kantian and Neo-Kantian systems. His own philosophical position is based on the phenomenological acceptance of the existence of an objectively real external world. Recognition of this external world is a relation between a personal subject and an object, a relation in which the transcendent object is the determining factor. The concept of the object thus gained by the subject does not correspond to the object itself but is a representation of it as seen or grasped by the subject. This interpretation of recognition is compatible with such ideas as truth—that is, the conformity of the representation with the object—and the progression of recognition—that is, the tendency of approximation of the representation to the object. Indeed, one of the strongest impressions one gains from the book is that of the infinite, inexhaustible character of the ontologic reality and, at the same time, of the infinite, limitless possible extension of our representation of it.

As evidence for the recognition, by prevalently a posteriori elements, of true aspects of nature, Max Hartmann has added a new chapter to the present edition, a chapter devoted to the "principle of convergence." This principle is illustrated by a diagram in which the recognizing subject is represented by a large circle and the transcendent object by a smaller circle, the two circles being connected by two or more lines which converge on the object circle. Each line signifies an independent relation of recognition of the object, and their convergence is seen as proof of the relative truth of recognition. The most convincing demonstration of the principle of convergence is seen in the independent determination of Loschmidt's number by more than nine different methods dealing with different phenomena. No attempt, however, is made to demonstrate that the convergence of these determinations is not based on common elements in the methodology rather than on the transcendent unity of reality.

This is a difficult book, concerned with a difficult area of thought. Its depth cannot be explored in a single reading. It will reward the student with new insights and stimulate him to further contemplation of the problems in the philosophy of science.

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Space Research. Hilde Kallmann Bijl, Ed. North-Holland, Amsterdam; Interscience, New York, 1960. xvi + 1195 pp. Illus. $24.

Space Research contains the approximately 100 papers presented at the symposium sponsored by COSPAR and held at Nice, France, during January 1960. The topics covered by the papers include the earth's atmosphere, the ionosphere, tracking and telemetering, solar radiation, cosmic radiation, interplanetary dust, and the moon and planets. It is impossible in a short review to discuss the content of these papers individually, but I should like to point out that almost all of the papers report on original research conducted by the authors and that the authors utilized satellites and space probes launched by the U.S. and by the U.S.S.R. For this reason the collection will, no doubt, form a nucleus of source material for a considerable time to come.

It is unquestionably a unique occurrence in the history of science when a new field can have most, if not all, of the pertinent observations collected in one volume at so early a stage in its development. The program committee responsible for the choice of papers given at the meeting is to be congratulated on its able decisions in selecting the contributors and in the complete and thorough coverage of the observational material made available. Last but not least, the editor of this volume, Hilde Kallmann Bijl, deserves unreserved praise for making this outstanding volume available in so short a time.

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Reports

Territorial Behavior in Uganda Kob

Abstract. Territorial behavior of the Uganda kob, *Adenota kob thomasi* (P. L. Sclater), is largely the defense of small, fixed territories within a central area of concentrated territorial activity. This area is surrounded by a zone of more widely spaced territories. Females enter the territorial ground throughout the year for the purpose of breeding.

The well-defined pattern of year-around territorial behavior of the Uganda kob was discovered (*1*) in March 1957. Although other African antelopes exhibit territoriality, the behavioral pattern of the Uganda kob appears to be unknown among any of the other species. Initial interpretations were verified in several widely separated herds over the following 15 months, and from June through August 1959 an intensive study on marked animals was conducted to ascertain details of this behavior in the Semliki Game Reserve, 20 miles north of Fort Portal, Uganda.

About 10,000 Uganda kob occur in approximately 100 square miles of habitat included by the reserve and vicinity (*2*). The entire population utilized only 13 known territorial breeding grounds, suggesting that certain physiographic requirements limited the number of breeding grounds. Each ground was situated on a ridge, knoll, or slightly raised area characterized by short grass, good visibility, and proximity to a permanent stream. A territorial ground of average size consisted of a central area of intensive activity, about 200 yards in diameter, containing 12 to 15 more or less circular territories varying from 20 to 60 yards in diameter. Some had common boundaries; others were separated by neutral areas. The territories were fixed in position and could be recognized by a central area of closely cropped grasses on heavily trampled ground and boundaries clearly demarcated with longer, less grazed grasses. In the surrounding peripheral area, a zone 100 to 200 yards wide, about twice as many territories were found as in the central area. Territorial breeding grounds remained in the same locations from July 1957 to September 1959. Apparently the grounds are seldom shifted to new locations. Territorial behavior occurred throughout the year, with slight peaks of intensified activity during the two rainy seasons (April to May; October).

Fifty territorial males were captured by the use of paralyzing drugs and marked for identification (*3*) at three territorial grounds separated from each other by distances of 2 to 2½ miles. Only about a third of the tagged individuals were seen again on territories, but almost invariably an individual returned to the same territory it had occupied previously. Some males remained on territory less than a day, others for several days or a few weeks. The longest record was 2½ months. During occupancy of a territory the male left once or twice in daylight to obtain water and forage. Observations on about 50 additional territorial males marked naturally by scars, abscesses, broken horns, and other characteristics showed that individuals not subjected to the experience of capture returned to territories in about the same frequency as marked individuals. A high rate of exchange of individual males within individual territories seems to be a natural feature of the behavior pattern.

Exchange of males on a given territory involved serious fighting between the occupant and a challenging male, the latter running in rapidly, through the peripheral area, into the central area of activity to what appeared to be a predetermined territory, perhaps one that he had occupied previously. This pattern and other aspects of territoriality of Uganda kob have been documented in a 30-minute motion picture film, in sound and color (*4*). Fights for possession of a territory were the longest and most serious of the fights observed. Two deaths positively attributable to fighting were recorded. Successful fights in which the challenging male defeated the occupant of a territory and took possession were observed about a dozen times; more frequently unsuccessful challenges were observed, some of which involved hard fighting. Often males ran into the central area only to be chased out by territorial males, each making short runs or threatening gestures in relay until the invader ran out of the prized area.

Defense of boundaries between occupied territories was accomplished mostly by ritualized display rather than intensive fighting. For example, to maintain the integrity of territories, males frequently walked toward one another with lowered ears and met at the boundary without fighting. Feigning and dodging with lowered heads with slight, if any, clashing of horns was also characteristic of ritualized defense of boundaries. Often brief fights were precipitated by females entering the territorial ground to breed. In attempting to attract the female by driving her toward the territory with prancing display, a male sometimes ran into neutral ground or unoccupied territories. If he approached an occupied territory too closely, vigorous fighting in defense of the boundary ensued. However, without disturbance from outside, serious fights were infrequent, territorial boundaries being maintained through mutual respect and ritualized display. When a female chose to leave one territory (*A*) for an adjacent territory (*B*), male *A* stopped at his boundary and permitted the female to walk into territory *B* without attempting to fight with male *B*. When disturbed by lion, automobile, elephant, or similar influence, the kob deserted the territorial ground by leaving along established routes. No antagonism between males occurred during such movements. Within 10 to 20 minutes after the disturbance was removed, the kob were again on their individual territories, brief fights occurring frequently as they reestablished themselves.

High population density may be essential for expression of territorial behavior of Uganda kob. In the Rutshuru Plains of the Congo, about 150 miles south of the Semliki Game Reserve, F. Bourlière (*5*) of the Faculty of Medicine in Paris did not observe the behavior in the same subspecies of kob, but the density of the population in the former region was about half of that in the latter.

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Instructions for preparing reports. **Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.**

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

References and Notes

1. I am indebted to my wife, Jimmie, for her keen observation and unbiased interpretation that led to the discovery of territorial behavior in Uganda kob. Research during 1957 and 1958 was supported by a Fulbright appointment and financial assistance from the Uganda Administration; in 1959 a grant in aid of research from the National Science Foundation permitted concentrated study of the phenomenon. Personnel of the Uganda Department of Game and Fisheries and the Uganda National Parks assisted greatly in field operations.
2. Estimation of the population from aerial counts was made in May 1958 with Dr. William M. Longhurst, University of California, who piloted a Stinson Voyager generously loaned to us by C. D. Margach, Kinyala Estates, Misindi, Uganda.
3. H. K. Buechner, A. M. Harthoorn, J. A. Lock, *Can. J. Comp. Med. Vet. Sci.* **24**, 317 (1960).
4. The film may be rented through the Audio-Visual Center at Washington State University, Pullman.
5. F. Bourlière, verbal communication.

28 October 1960

Bioluminescence in Chesapeake Bay

Abstract. Bioluminescence measurements made by stimulation of the organisms in a jet of water directed at the face of a phototube have increased the sensitivity of data by a factor of 1000 over "spontaneous" luminescence measurements. In light-baffled cells it has been possible to map the surface bioluminescence of large areas continuously in broad daylight. Measurements of intensity versus depth during both day and night do not show any appreciable diurnal variation in maximum intensity, although there does appear to be a vertical migration of intensity.

Measurements of bioluminescence in several regions of the Chesapeake Bay indicate that light-emitting microscopic marine organisms have a wide and general distribution in these waters. The equipment was designed to measure bioluminescence independent of external incident radiation. The sample cell consisted of a defined volume of 9 by 12 by 12 inches, open to the sea above and below but sufficiently light-baffled so as to exclude the effects of incident sunlight at the water surface even in broad daylight.

Light emission by many microscopic organisms occurs only on stimulation; consequently, in order to obtain a true measure of the luminous organisms present it is necessary to stimulate the population immediately in front of the photocell. This was done by means of a miniature impeller-type pump directing a small jet of water directly toward the face of an EMI 1-inch phototube, which was mounted on the opposite side of the sample cell housing. The turbulence in the jet stream was sufficient to stimulate emission of light in those organisms within the stream. The total volume of the sample cell was large enough to replenish, by convection to the jet stream, those organisms which had not yet been stimulated.

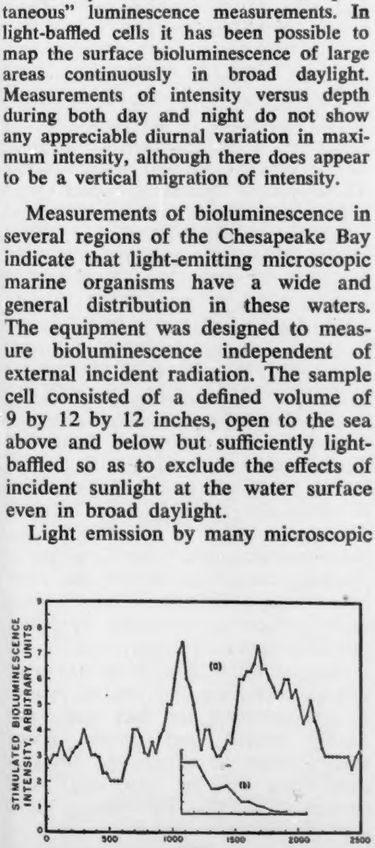

Fig. 1. Mapping record of stimulated bioluminescence in the channel of the Little Choptank.

This method of nondestructive stimulation increased the sensitivity of the bioluminescence measurements by more than a factor of 1000 over that obtainable by measuring "spontaneous" bioluminescence. These features provide what is considered to be a more precise and much more sensitive parameter for estimating the density of bioluminescent organisms than that described by G. L. Clarke and his co-workers (*1*). Further, the present measurements were made from the surface to depths of 140 feet.

The sensitivity of the technique was such that continuous measurements of bioluminescence could be made when the unit was towed behind the boat at speeds of 3 to 4 knots. In Fig. 1 are shown partial records of stimulated bioluminesmence taken with the light-baffled cell at a depth of 1 foot in bright sunlight. The speed of the boat was 6 ft/sec.

Figure 1*a* shows a representative mapping record over a distance of 2500 feet, as the boat was coming out of the channel of the Little Choptank River into Chesapeake Bay proper. The bioluminescence light intensities are not uniform and indicate the presence of "blooms" or colonies of bioluminescent organisms. Figure 1*b* is a portion of the mapping record showing the decrease in bioluminescence light intensity as the boat came into the main channel of the bay where the tide was running. The bioluminescence intensity measured in this particular mapping experiment extended over a range of 740. At the lowest level measured, at rip tide in the bay channel, the signal-to-noise ratio was still 300.

Figure 2 shows stimulated bioluminescence intensity as a function of depth made at anchor over a 140-foot hole in the bay floor. There is a shift in peak intensity with depth from about 25 feet during the day to just below the surface at night.

An important point is that there is no striking difference between the maximum light intensities measured in daylight and at night; in fact, the daylight intensities were all slightly higher. This would indicate that the light-inhibition of bioluminescence previously reported for the larger organisms, such as *Mnemiopsis* by E. N. Harvey (*2*), may not be general or else may be a secondary physiological response. Using laboratory cultures of the dinoflagellate *Gonyaulax polyhedra*, Sweeney and Hastings observed a diurnal rhythm of of luminescence. (*3*). Cells grown in daylight showed a dim luminescence during the day which increased in brightness at night. The bright luminescense observed at night could be inhibited by light. It was surprising, therefore, that such a rhythm was not observed in the bay. From the data presented in Fig. 2, it appears that the organisms migrate to a deeper region during the day and consequently maintain maximum luminescence.

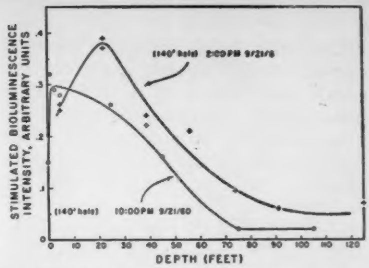

Fig. 2. Stimulated bioluminescence as a function of depth for day and night.

A careful study of the relationships between photosynthesis and luminescence in these organisms may reveal that the type of rhythm observed by Hastings and Sweeney is offset in nature by a rhythmic vertical movement which prevents exposure to strong illumination. Additional studies on the type and number of organisms present are necessary before any definite conclusions can be made.

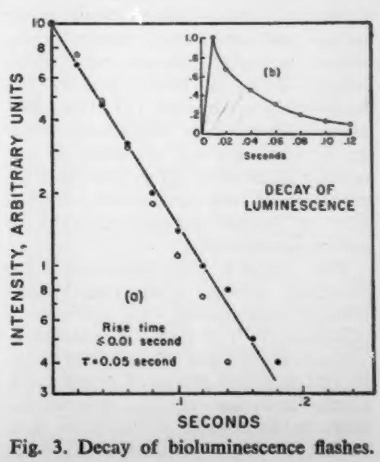

Fig. 3. Decay of bioluminescence flashes.

Individual flashes were also observed and recorded. With only one exception, which may have been a small ctenophore which penetrated the baffle and screen cover of the sample cell, all of the hundreds of flashes observed were extremely short bursts lasting only 0.1 or 0.2 second. The decay time of some representative flashes is shown in Fig. 3*a* to be first order with a mean life of 0.05 second. A complete flash is shown in Fig. 3*b*. The rise time of 0.01 second is the limit of the high frequency response of the d-c amplifier used in the equipment. The actual rise time may be much shorter (*4*).

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References and Notes

1. G. L. Clark and C. J. Hubbard, *Limnol. and Oceanog.* 4, 163 (1959); G. L. Clarke and L. P. Breslau, *Bull. inst. oceanog.* 56, No. 1147 (1959); 57, No. 1171 (1960).
2. E. N. Harvey, *J. Gen. Physiol.* 7, 331 (1925).
3. B. M. Sweeney and J. W. Hastings, *J. Cellular Comp. Physiol.* 49, 115 (1957).
4. This work was performed under a grant from the Office of Naval Research. The assistance of the Chesapeake Bay Institute of Johns Hopkins University in providing their research vessel *Maury* is gratefully acknowledged.

10 November 1960

Production of Biologically Active Compounds by Isolated Lichenized Fungi

Abstract. Fungi which were separated from their lichenized associations and cultured independently produced several unusual and highly pigmented compounds. Certain of these compounds exhibited marked inhibitory activity against test strains of gram-positive bacteria and free-living molds; others showed a growth stimulatory effect on selected bacterial species.

The fact that lichens form many unique and interesting chemical compounds (so-called lichenic acids) which possess strong antibiotic activity has been firmly established (*1*). Unfortunately, lichens are notoriously slow growers and are not amenable to laboratory cultivation. Thus, practical exploitation of such compounds is limited only to lichens growing naturally in sufficient abundance.

Few workers have investigated the possibility of the lichen fungal component's synthesizing such active compounds apart from the algal association. Thomas (*2*) isolated many lichen fungi, several of which produced lichen acids. Castle and Kubsch (*3*) showed the presence of several lichen acids in a culture of the mycobiont of *Cladonia cristatella*. The activity of these acids was not tested. Zehnder (*4*) demonstrated a strong inhibition of the mold *Penicillium* sp. by the mycobiont of *Lecanora subfusca*; he did not describe the active compound.

In our investigation, 11 pure cultures of mycobionts were tested for active compounds. The mycobionts were separated from the following lichens: *Acarospora fuscata, A. smaragdula, Baeomyces roseus, Cladonia cristatella, C. pleurota, C. subcariosa, Graphis* sp., *Lecanora chlarotera, Physcia stellaris, Sarcogyne simplex*, and *Stereocaulon dactylophyllum* var. *flabellatum*. The mycobionts were isolated by means of the cultivation of spores ejaculated onto the surface of a soil-extract agar medium (*5*). Small portions of the agar which were free from contamination and showed a high percentage of germinating spores were then transferred to tubes which contained a malt extract and yeast extract agar (*p*H 5.8).

After 3 to 4 months of growth in complete darkness or low light intensity (20 to 25 ft-ca) at 17° to 18°C, the fungal colonies assumed various shapes, sizes, and pigmentation, each species passing through an initial white mycelial stage. In mycobionts *Acarospora fuscata* and *A. smaragdula* a bright red, water soluble pigment, which colored both the colony and surrounding medium, was produced by the hyphal cells. This single pigment showed a high degree of variation in color, ranging from bright red and purple to yellow and brown; the color changes and the amount of pigment produced appeared to be influenced by variations of temperature, *p*H, light intensity and carbon dioxide concentration. In *Cladonia cristatella, C. pleurota, C. subcariosa*, and *Stereocaulon dactylophyllum* var. *flabellatum*, the maturing fungal colonies changed color from white to pure yellow to red to reddish-brown or dark brown. Conditions and compounds which caused the color changes of these mycobionts were not investigated. In *Cladonia pleurota* a bluish pigment also developed in some parts of the colony. The mycobiont of *Baeomyces roseus* produced an orange pigment, and the hyphal cells were filled with abundant oil droplets. The mycobiont of *Lecanora chlarotera* was bright yellow in color and produced a water-soluble, dark brown pigment.

Acetone extracts of the fungal colonies, picked directly from tubes of a malt extract and yeast extract agar, were assayed with standard paper disk-agar plate techniques. Test organisms were selected strains of *Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Aspergillus niger*, and *Penicillium chrysogenum*.

Results of the assay tests can be summarized as follows: Extracts of *Acarospora fuscata, A. smaragdula*, and *Cladonia cristatella* produced definite zones of inhibition against *Bacillus subtilis* and *Staphylococcus aureus*, the degree of inhibition being greater against *Bacillus subtilis*. The extract of *Acarospora smaragdula* was alone in inhibiting the two test molds. Acetone extracts of the remaining mycobionts showed no activity against the test organisms. None of the extracts showed activity against *Escherichia coli*.

The mycobiont of *Acarospora smaragdula* seemed to produce three types of compounds. During its initial growth phase, the fungus excreted large quantities of the water soluble, red-yellow-brown pigment mentioned above; this pigment was formed both on solid and in liquid media. The pigment showed strong inhibition of the two test fungi, no inhibition of the test bacteria, but an enhancement of growth of *Bacillus subtilis*. In later growth stages of the mycobiont, abundant prismatic plate-like crystals were found in the regions of agar where the pigment had diffused and also on the hyphal cells. These crystals were insoluble in water and acetone and found only on solid media. In older cultures of the mycobiont, bright yellow, plate-shaped structures appeared directly on the fungal colony and also on the agar surface in areas of the greatest pigment concentration. These yellow structures, which were produced only on solid media and which were readily soluble in acetone and insoluble in water, appeared amorphous under microscopic examination but were easily crystallized by the method of Asahina (*6*). Disks soaked in an acetone solution of such structures and then air dried to remove the solvent showed strong inhibition of *Bacillus subtilis, Staphylococcus aureus, Streptococcus fecalis, Aspergillus niger*, and *Penicillium chrysogenum*, with no activity against *Escherichia coli* and *Pseudomonas aeruginosa*. Evidence obtained from crystallization, chromatography, color reactions, and absorption spectra showed a similarity between this compound and a sample of known usnic acid produced commercially by Nutritional Biochemicals Corporation.

Study of a few lichen fungi has given several interesting and fruitful results. If one considers the fact that some 15,000 unique and diverse lichen species occur in nature, the research possibilities on the physiology and chemistry of the mycobionts alone seem limitless. (*7*).

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References and Notes

1. P. R. Burkholder and A. W. Evans, *Bull. Torrey Botan. Club* **72**, 157 (1945); F. Bustinza, *Anales Inst. botan. A. J. Cavanilles (Madrid)* **2**, 1 (1953).
2. E. A. Thomas, *Beitr. Kryptogamenflora Schweiz* **9**, 1 (1939).
3. H. Castle and F. Kubsch, *Arch. Biochem.* **23**, 158 (1949).
4. A. Zehnder, *Ber. schweiz. botan. Ges.* **59**, 201 (1949).
5. H. C. Bold, *Botan. Rev.* **8**, 114 (1942). Medium No. X(2); pH of extract used in this investigation = 6.0.
6. Y. Asahina and S. Shibata, *Chemistry of Lichen Substances* (1954).
7. This study was supported by grants from the National Institutes of Health (No. E-3431) and the National Science Foundation (No. G-13049). Acknowledgement is made of the technical assistance of Mrs. J. P. Roche.

9 January 1961

Delayed Alternation in Hemicerebrectomized Monkeys

Abstract. Monkeys subjected to extensive unilateral brain extirpation learned a delayed alternation task, although their rates of learning were significantly lower than those of a control group of normal animals. Visual field defects did not seem to account for the deficit.

It was recently reported that impairment on the delayed alternation task could be ". . . turned on and off . . ." by unilateral electrical stimulation to the sulcus principalis of the monkey brain (*1*). Earlier, deficit on this task had often been reported in monkeys as a result of bilateral damage to brain tissue, specifically the midlateral frontal cortex (*2*). Few studies, however, reported impairment after unilateral lesions (*3*). In each case of unilateral lesion the deficit was temporary, and in none did the animals undergo unilateral extirpations of the brain to the extent of those to be reported here.

The surgical procedure, hemicerebrectomy (*4*), involves the unilateral removal of all cerebral structures lateral to the hypothalamus and rostral to the midbrain (Fig. 1). Since a similar but less extensive operation has been applied to the treatment of certain neurological disorders in humans—for example, tumor, infantile hemiplegia, and epilepsy (*5*)—the resulting effects of hemicerebrectomy upon learning and retension abilities of primates are of considerable importance. Consequently, a series of experiments was designed to evaluate the behavior of hemicerebrectomized monkeys. The experiment discussed in this report utilized delayed alternation performance to measure one aspect of learning ability.

The subjects were immature rhesus monkeys, five normal and five hemicerebrectomized, that had received previous training on object-quality discrimination problems. Feeding was scheduled so that the subjects had been deprived of food for about 22 hours at the time of testing and, therefore, were well motivated for the raisin rewards.

An adaptation of the Wisconsin general test apparatus was located in a room in which normal laboratory noises were greatly muffled. The stimuli consisted of a single pair of identical objects (plain, black, wooden blocks, measuring 4¼ by 2¾ by ¾ in.), which covered two food wells that were located about 11½ in. apart in a light gray presentation tray. The wells were baited during a 10-second delay, while the opaque screen was interposed between the subject and objects. To serve as a starting point for the alternation sequence, displacement of either object was rewarded on the first trial, and subsequently 50 more trials were given each day.

The problem required the subject to alternate from a just previously rewarded choice to the object on the other side. By following a noncorrection procedure, a criterion of at least 86 percent correct responses over two consecutive days was used.

Normal animals required significantly fewer days to reach criterion than did the operated subjects (*6*). The latter, in fact, took over twice as long (Table 1). Figure 2 presents graphic data for the course of learning in each group. A pronounced overlap may be noted for the first 4 days, but after that time the curve of the normal group remains higher.

Although homonymous hemianopsia is an expected result of this surgery, the visual field defect did not seem to account for the delayed alternation deficit in these subjects. The animals demonstrated past high performance levels on visual discriminations between two dissimilar objects. Because the possibility existed that the field defect might be related to side preferences, the numbers of both total responses and errors made by each subject to each side were tabulated. In neither case did the operated subjects show a side preference significantly different from that of the normal subjects (*7*).

Even though the hemicerebrectomized group exhibited a level of performance lower than that of the normal group, it is believed more important to stress that the operated monkeys did meet the criterion of learning. This accomplishment emphasizes the observation that, several months after surgery, the hemicerebrectomized monkeys still retained structures necessary to the learning of this task.

The hemicerebrectomized monkey provides a useful preparation in which to study the function of remaining structures with an increased certainty, prior to histology, regarding the bilaterality

Table 1. Number of days to criterion on delayed alternation. The data on delayed alternation performance has been supplemented by scores from another group of hemicerebrectomized monkeys with a similar background, which was not discussed in the text.

Subject No.	Days
Normal group	
126	10
127	17
129	13
130	13
135	20
Mean	14.6
Operated group	
106	31
116	24
121	31
123	42
124	37
Mean	33.0
Other operated animals	
109	54
112	27
113	18
120	27
122	46
Mean	34.4

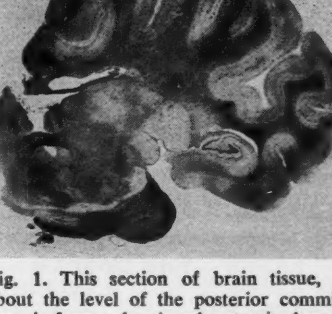

Fig. 1. This section of brain tissue, at about the level of the posterior commissure, is from a hemicerebrectomized monkey. The Kluver and Barrera double stain technique was used.

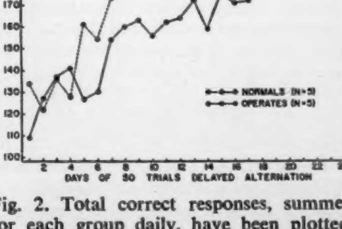

Fig. 2. Total correct responses, summed for each group daily, have been plotted. Totals for only the period during which each group remained intact are shown; that is, before any subject in each group met the criterion.

of subsequent surgical intervention. For example, previous work which has implicated the caudate nucleus with deficit on delayed alternation in the monkey (*8*) could be supplemented by this approach. Since the extensive extirpation permits relatively easy access to some remaining subcortical structures, which are generally difficult to reach, it is believed that this technique can provide a useful tool for further study of the role played by the subcortex in various tasks (*9*).

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References and Notes

1. L. Weiskrantz, L. Mihailović, C. G. Gross, *Science* **131**, 1443 (1960).
2. M. Mishkin and K. Pribram, *J. Comp. and Physiol. Psychol.* **48**, 492 (1955); K. Pribram and M. Mishkin, *ibid.* **49**, 41 (1956); M. Mishkin, *J. Neurophysiol.* **20**, 615 (1957).
3. C. F. Jacobsen and H. W. Nissen, *J. Comp. Psychol.* **23**, 101 (1937); H. E. Rosvold and J. M. R. Delgado, *J. Comp. and Physiol. Psychol.* **49**, 365 (1956); H. E. Rosvold and M. Mishkin, paper read at meetings of Eastern Psychological Assoc., New York, 1960.
4. The surgical procedure has been reported by Y. D. Koskoff, R. A. Patton, B. Migler, D. Kruper, *Cerebral Palsy Rev.* **20**, 3 (1959).
5. R. Krynauw, *J. Neurol. Neurosurg. Psychiat.* **13**, 243 (1950); Y. D. Koskoff, *Cerebral Palsy Rev.* **18**, No. 2 (1957).
6. With the Mann-Whitney U procedure, a p of 0.004 was found.
7. With the Mann-Whitney U procedure, on left versus right responses a p of 0.075 for total responses and a p of 0.210 for errors were found.
8. H. E. Rosvold and J. M. R. Delgado, *J. Comp. and Physiol. Psychol.* **49**, 365 (1956); M. Mishkin, *J. Neurophysiol.* **20**, 615 (1957); B. Migler, thesis, Univ. of Pittsburgh (1958).
9. This research has been supported in part by grants from the U.S. Public Health Service and the United Cerebral Palsy Foundation.

26 October 1960

High Incidences of Transmissible Kidney Tumors in Uninoculated Frogs Maintained in a Laboratory

Abstract. Various workers have shown that the Lucké carcinoma, a transmissible kidney tumor of the leopard frog, occurs spontaneously at low incidence (6.7 percent maximum). However, we have consistently observed much higher incidences (50 percent maximum), a finding of probable significance in the epidemiology and natural transmission of the tumor. Age, metabolic level, and cross infection are being investigated as possible factors in determining the tumor incidence.

Kidney tumors of the type described by Lucké (*1*) are occasionally seen in leopard frogs (*Rana pipiens*) collected in the region surrounding Lake Champlain, Vermont. In the only extensive studies of spontaneous incidence, Lucké found tumors in 2.7 percent of newly caught frogs, and in 6.7 percent of uninoculated frogs kept in the laboratory for periods ranging from 6 months to 1 year or more (*2*). However, nine uninoculated groups maintained intermittently by us as controls in tumor transmission studies have in nearly every instance shown much higher incidences of tumors at the end of 6 months (*3*).

All groups are represented in Table 1, which shows that incidences ranging between 20 and 50 percent were observed between the 30th and 41st weeks. One particular group (group 5) was examined in greater detail. Of 87 frogs which survived for 30 weeks or died before that time with kidney tumor, 12 developed palpable tumors. The remaining 75, killed and autopsied at the end of 30 weeks, yielded two small tumors, as confirmed in histological sections, and four cases in which blanched, nodular areas were seen in the kidneys. On section, three were seen to be helminthic in origin, but the fourth was a small, although a typical, case of Lucké tumor.

Finally, normal-appearing kidneys from ten male and ten female frogs were fixed, and center segments representing one-fourth of each pair were sectioned serially. This method was adopted in order to survey the material without the laborious process of sectioning entire kidneys. The conservative assumption was adopted that histologically normal center sections represented normal kidneys. Among the 20 pairs of kidneys so sectioned, two were found which bore microscopic but typical and unmistakable tumor foci. Thus, 17 tumors (20 percent) were found among the original 87 frogs. However, it is estimated, on the basis of the two microscopic tumors found, that five microscopic tumors might have been expected in the remaining 52 pairs of kidneys which were grossly normal in appearance, but which were not sectioned. If so, the total number of tumors present in the group would be 22 or 25 percent.

Table 1 indicates that a considerable increase in the number of tumors is to be expected after 30 weeks. For that reason, the 18 remaining normal-appearing pairs of group 5 kidneys which were sectioned were also scored for the presence of the presumptive tumor transitional changes observed by Duryee (*4*, *5*). Such changes were described by him on the basis of abnormal cells which occurred in tumor-bearing kidneys and in kidneys of frogs inoculated with Lucké tumor filtrates.

Of the 20 pairs of kidneys which we scored, four showed advanced tubule changes suggesting borderline neoplasia, while six others showed slight-to-moderate change of the same character. These ten cases consisted of occasional nephrons in which the proximal convoluted portions of the tubules showed nucleolar enlargement, pronounced basophilia, numerous cytoplasmic inclusions of various types, and mitotic figures (see *4*). Similar changes were not seen by us in the kidneys of several dozen frogs killed immediately upon arrival in the laboratory, but the changes were abundantly seen in a majority of cases in which frogs were inoculated with tumor-derived materials and examined histologically at a later date.

On the basis of an assumption, currently being tested, that kidneys bearing nephrons of transitional appearance are destined for neoplasia, it is estimated that of the total group of 87 frogs, 41 percent (36 individuals) either bore kidney tumors (25 percent) or were in preneoplastic condition (16 percent), if only the four advanced cases of transitional change are considered. As shown in Table 1, this figure agrees well with the incidence actually found in groups which were maintained a few weeks longer before their death, and suggests that such kidneys were destined to become grossly neoplastic within about 8 weeks.

When all ten cases with nephrons of the presumed transitional type are considered, it is estimated that 66 percent of the total group (25 percent bearing kidney tumors, plus an additional 41 percent in the transitional state) bore the tumor or were destined to develop tumors. This figure should be compared with Duryee's figure of 56 percent for combined transitions and kidney tumors in frogs inoculated with tumor filtrates and examined after 4 months or less (*4*).

The factors responsible for the observed high incidence of Lucké tumors are not yet known. However, environmental factors related to temperature and metabolic level, to age, and possibly to opportunities for laboratory cross-infection or contamination differed

Table 1. Occurrence of kidney tumors in uninoculated frogs maintained in the laboratory.

Group	Frogs (No.)	Time kept (wk)	Kidney tumors (No.)	Kidney tumors (%)
1	10	9	1	10
2	20	11	1	5
3	12	13	3	25
4	20	24	0	0
5	87	30	17	20
6	8	31	2	25
7	10	33	5	50
8	10	39	5	50
9	20	41	7	35
Total	197		41	
Mean		30		21

in these experiments from those reported by others who have not observed high incidences of the tumor (*2, 4*). Experiments are planned to determine which, if any, of the factors named can influence the tumor incidence.

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References and Notes

1. B. Lucké, *Am. J. Cancer* **20**, 352 (1934).
2. ———, *Ann. N. Y. Acad. Sci.* **54**, 1093 (1952).
3. This work was aided by grant No. E-163 from the American Cancer Society.
4. W. Duryee, *Ann. N. Y. Acad. Sci.* **63**, 1280 (1956).
5. ———, *Acta Unio Intern. contra Cancrum* **15**, 587 (1959).

4 November 1960

Interaction of Chromatid Breaks Produced by X-rays and Radiomimetic Compounds

Abstract. The results of combination treatments of the roots of *Vicia faba* with certain radiomimetic compounds (8-ethoxycaffeine, maleic hydrazide, β-propiolactone, potassium cyanide) and x-ray as well as combination treatments of certain radiomimetic compounds with one another were observed to determine whether interaction will occur between chromosomal breaks induced by different agents. Interaction was observed between breaks induced by x-rays and all of the breaks induced by chemicals but not between breaks induced by any two chemicals. The results are discussed in terms of possible breakage bond differences and the effects of temporal and spatial differences in breaks induced by different agents.

It has been known for some time that treatment with certain chemicals classed as radiomimetic results in chromosomal aberrations that are indistinguishable, when observed at metaphase, from radiation-induced changes. Whether or not the breaks induced by these compounds are qualitatively similar to one another and to radiation-induced breaks is still a moot point. Evidence at this time indicates that regardless of the similarity or dissimilarity of the breaks, the areas in which the breaks induced by a given compound occur are often quite specific. For example, in *Vicia faba*, the chromosomal breaks induced by 8-ethoxycaffeine are most frequently located in the nucleolar organizer region of the satellited chromosomes. Breaks induced by maleic hydrazide are most frequently observed in the two segments of heterochromatin located on either side of the centromere of the satellited chromosomes. Breaks induced by radiation seem to be more at random. They are observed in euchromatic as well as heterochromatic regions, and the frequency with which breaks occur in the long as against the short chromosomes approaches randomness.

Wolff and Luippold (*1*), in their studies of the rejoining system, and Cohn (*2*), in his study of the interaction of x-ray-induced breaks, have demonstrated that whatever the nature of the bonds broken during treatment with x-rays there is sufficient similarity between enough of these ruptured bonds to result in the interaction of broken ends. That all or most x-ray-induced breaks are similar enough to interact is indicated by the fact that Cohn observed a frequency of interaction as great as that which he calculated for complete interaction (*2*). It is feasible, in the light of existing evidence, to consider that all breaks, no matter what their origin or chemical nature, interact through the mediation of a common repair system that does not distinguish between one broken bond and another so that the difference between an interchange and a noninterchange situation is a function only of availability of the breaks in terms of time and space and not of chemical differences between the bonds that are broken.

It is of some interest to test the hypothesis that all breaks, no matter what their nature, can interact with one another. One method would be to confront the "rejoining system" with breaks induced simultaneously by different agents and observe the amount of interaction taking place. These breaks would be randomly dispersed or concentrated in specific localities in the chromosomes, depending on the agent or agents employed.

Specificity in terms of localized breakage can be explained in two ways. First, the compound may be incorporated at specific sites and is therefore restricted in its action to a few localities. The only evidence bearing on this point makes this an unlikely hypothesis since autoradiographic studies of tritiated 8-ethoxycaffeine indicate that at least this compound is not incorporated at the site where most of the damage is observed (*3*). Second, specificity can be explained by assuming that an agent inducing breaks in specific localities in few or all chromosomes is capable of producing breaks in one or few kinds of bonds which occur rarely along the length of the chromosomes. Conversely, an agent inducing breaks which are randomly located along the length of all chromosomes can be considered capable of producing breaks in several kinds of bonds, or, assuming some specificity of action, of breaking a particular bond that is exceedingly common along the length of the chromosomes. Regardless of the explanations for observed localized breakage, it is of interest to test whether or not breaks induced at specific sites by particular agents interact with other breaks, randomly or specifically located.

The experimental material used in the following experiments (*4*) consisted of lateral root tips of the broad bean, *Vicia faba*. The variety used, Seville Long Pod, was obtained from Carter's Tested Seeds Limited, London, England. The roots were grown in shell vials in the dark at 25°C for 6 days following an initial 24-hour period of soaking. The tap water was changed twice daily during growth and recovery (the latter being the time interval between treatment and fixation). Twenty-four hours before treatment the roots were placed in an incubator at 17°C. Treatments were performed at 20°C, and recovery took place at 17°C, in the dark. The root tips were treated with 0.05 percent colchicine for 3 to 4 hours before fixation in a cold mixture of alcohol and acetic acid (3:1), and slides were prepared as Feulgen squashes. The treatments were carried out in shell vials and were performed in three different ways.

The two agents that induce breaks whose ability to interact was being tested were introduced simultaneously, and each was used as pretreatment for the other. The agents used to induce specific and randomized breaks are as follows: β-propiolactone, potassium cyanide, 8-ethoxycaffeine, maleic hydrazide, and x-rays. Dinitrophenol was also used in an occasional experiment to keep the breaks open between treatments (*1*) to determine whether or not it had any effect on the exchange frequency (interaction) (*2*). The following molar concentrations of the various agents were use: β-propiolactone, 7×10^{-3}; KCN, 1×10^{-3}; 8-ethoxycaffeine, 1×10^{-3}; maleic hydrazide, 2×10^{-4}; dinitrophenol, 1×10^{-4}. The x-ray dose, when used, was 100 r.

Results of the different combination treatments are summarized in Table 1. The experiments listed here are based on the assumption that x-ray-induced breaks, being more or less randomly distributed, are likely to include amongst them enough broken bonds similar to those induced by radiomimetic compounds that interaction will result from combination treatments including radiation as one of the agents. Conversely, combination treatments with two agents that induce breakage in relatively localized areas are likely to break few, if any, similar bonds, and therefore

interaction will not result from these treatments.

The results of these treatments seem to bear out this assumption. All the combination treatments that include x-rays and a radiomimetic compound result in interaction. Combination treatments with agents that induce breaks in rather specific chromosomal areas do not appear to result in interaction of these breaks. In the case of 8-ethoxycaffeine and maleic hydrazide, where the breaks are localized in the satellited chromosomes, interaction, if it occurs, can be observed directly. If it is assumed that interaction takes place, exchanges would be expected between the nucleolar organizer region (induced by 8-ethoxycaffeine) and the heterochromatic regions proximal to the centromere of the long chromosomes (induced by maleic hydrazide). Instead, all exchanges in the satellited chromosomes involving one or the other of these two break points always involve identical break points in both chromosomes. None of the combination treatments resulting in interaction showed any change in exchange frequency in the presence of dinitrophenol, nor did the frequency differ when the order in which the agents were presented was shifted. This, of course, was to be expected when KCN was used, for it has the same depressant effect on the rejoining system as dinitrophenol. No experiments in which KCN was combined with either 8-ethoxycaffeine or maleic hydrazide could be carried out, nor could dinitrophenol be used with the 8-ethoxycaffeine–maleic hydrazide combination treatments to inhibit rejoining, because the resulting decrease in exchange frequency produced by these two compounds in the presence of KCN or dinitrophenol is too great to permit the determination of any degree of interaction.

The results obtained, although supporting the assumption made previously, can be variously interpreted. It can be argued, as Auerbach (*5*) has (after having demonstrated interaction between breaks induced by nitrogen mustard and by x-rays), that failure to observe interaction can be misleading in that breaks induced by two agents are so spaced temporally that restitution or rejoining of one set occurs before the other set of breaks has been induced. Since the breaks induced by one agent may be concentrated in a completely different mitotic stage than breaks induced by the second agent, breaks induced by both agents during the relatively short treatment may only rarely occur at the same time in the same cell. Interaction obviously would not occur under these circumstances even though the breaks may be qualitatively similar and are otherwise capable of interaction.

This argument adequately explains some of the results listed in Table 1 if removed from the context of other results listed therein. For example, the combination treatment with x-rays and 8-ethoxycaffeine produced an exchange frequency to be expected if interaction occurred. These are agents that are dissimilar in localization pattern (*6*), but the breaks induced by both of them are so placed temporally that they are hard to distinguish. Interaction therefore is to be expected if the previous argument is assumed to be correct even though these agents (x-rays and 8-ethoxycaffeine) are quite dissimilar in many ways. Auerbach's hypothesis would also explain the results observed after combination treatments with 8-ethoxycaffeine and maleic hydrazide, which are temporally quite different (*7*) and which do not seem to induce breaks that interact, and after treatments with KCN and β-propiolactone (*8*, *9*) that also do not result in interaction. In the latter case, however, one might expect a change in the temporal differences between the two compounds since the presence of KCN results in an inhibition of the rejoining system, thus increasing the probability of interaction (*1*). Interaction, however, is not indicated by the exchange frequency resulting from this combination treatment.

The argument that noninteraction results from temporal differences between breaks induced by different agents fails when the results of the combination treatments are viewed as a whole. The highest frequency of breaks induced by x-rays seems to be produced at a different time in the mitotic cycle than breaks induced by KCN (*8*), maleic hydrazide (*7*), and β-propiolactone (*9*). It would therefore be expected that the breaks induced by the radiomimetic compounds would have rejoined before the x-ray-induced breaks occur and would not be available for interaction with succeeding breaks. This is evidently not the case, however, since the combination treatments produce exchange frequencies indicating that interaction has occurred. It would clearly be a most complex situation if one must state that when interaction does not occur it is the result of temporal differences but when interaction does occur temporal differences are of no importance. The data herein presented are certainly equivocal in the sense that mitotic inhibition may well distort the results so that simple comparisons between single treatments and combination treatments are difficult. This may well be the case in the 8-ethoxycaffeine–maleic hydrazide combination, where the exchange frequency as well as the isochromatid frequency obtained is well below what is to be expected on and additive basis. It is not the case in the KCN–β-propiolactone combination, where the exchange frequency does not indicate that interaction has occurred although it is not only as high but slightly higher than additive.

It seems reasonable at the moment to conclude that interaction may not *only* be a function of time and space but also that it may occur only between the same or very similar kinds of breaks, and that those breaks involving very different kinds of bonds do not

Table 1. Comparison of the interaction of chromatid breaks induced by x-rays and radiomimetic compounds in different combination treatments. BPL, β-propiolactone; EOC, 8-ethoxycaffeine; KCN, potassium cyanide; MH, maleic hydrazide.

Treatment	Cells scored (No.)	Normal (%)	Abnormal (%)	Isochromatids (%)	Exchanges (%)		
					Observed	If additive	Calculated for interaction
X-rays	750	73	27	24	5		
KCN	650	71	29	25	7		
KCN + x-rays	1300	46	54	37	23	12	24
X-rays	750	73	27	24	5		
BPL	500	44	56	54	22		
BPL + x-rays	200	26	74	68	54	27	49
X-rays	750	73	27	24	5		
EOC	200	87	13	14	1		
EOC + x-rays	200	63	37	24	12	6	11
X-rays	750	73	27	24	5		
MH	200	35	65	71	20		
MH + x-rays	200	25	75	64	45	25	46
EOC	200	61	39	42	6		
MH	200	40	60	62	15		
EOC + MH	200	53	47	56	8	21	40
KCN	300	85	15	14	5		
BPL	500	44	56	54	22		
BPL + KCN	200	30	70	74	34	27	49

interact to any appreciable extent, if indeed they interact at all. What this means in terms of chromosome structure is not yet clear. It is clear, however, that it cannot be assumed on the basis of the available evidence that interaction occurs through a common repair system that is unable to distinguish one broken bond from any other. It is possible that the repair system cannot join two unlike bonds or that there is more than one system operating in the process we call rejoining.

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References and Notes

1. S. Wolff and H. Luippold, *Science* **122**, 231 (1955).
2. N. S. Cohn, *Genetics* **43**, 362 (1958).
3. T. Merz, unpublished results.
4. This work was supported in part by the Atomic Energy Commission, National Science Foundation, and National Institutes of Health.
5. C. Auerbach, *Radiation Research* **9**, 33 (1958).
6. J. Read and B. A. Kihlman, *Hereditas* **42**, 487 (1956).
7. B. A. Kihlman, *J. Biophys. and Biochem. Cytol.* **2**, 543 (1956).
8. ———, *ibid.* **3**, 363 (1957).
9. C. P. Swanson and T. Merz, *Science* **129**, 1364 (1958).
* National Institutes of Health postdoctoral fellow.

8 July 1960

Fluorescence of Photosynthetic Organisms at Room and Liquid Nitrogen Temperatures

Abstract. Fluorescence spectra of algae and higher plants show two bands, ascribable to monomer and aggregate forms of chlorophyll. At low temperature, the long-wavelength emission is greatly enhanced and often appears as a new band. Photosynthetic bacteria, on the other hand, show no new bands at low temperature, within the spectral coverage and sensitivity of these measurements. A green fluorescence is also found in algae, which we attribute to carotenoids.

Fluorescence and absorption studies indicate that chlorophyll may exist in vivo in both monomeric and aggregated forms (*1–4*). Particularly strong evidence supporting this view has been given by S. Brody, who attributed a long-wave fluorescence appearing at low temperature to such an aggregate, on the basis of analogous behavior of concentrated chlorophyll solutions. It has been further suggested (*3–5*) that the decline of photosynthetic efficiency at long wavelengths, first observed by Emerson and Lewis (*6*), is due to preferential light absorption by this aggregated species. Other explanations have also been discussed for this long-wavelength decline (*7, 8*). In this report, we present a summary of new experiments on the fluorescence of various photosynthetic organisms which further extend the considerations mentioned above.

Fluorescence spectra were determined at room and liquid nitrogen temperatures (*9*) for various algae (*Ochromonas danica, Chlorella pyrenoidosa, Euglena gracilis, Porphyridium cruentum*), photosynthetic bacteria (*Rhodospirillum rubrum, Rhodopseudomonas palustris, Chromatium d*), and leaves of higher plants (*Prunus virginiana, Betula papyrifera*). These forms were selected as representative of various plant pigment systems.

Figure 1 shows typical fluorescence spectra of *Ochromonas*. The room temperature chlorophyll spectrum consists of a single broad band, with maximum at 685 mμ. At low temperature, two bands are found, shifted from the room temperature peak toward longer wavelengths by about 3 mμ and 20 mμ respectively. The effects are reversible. The low-temperature, long-wave emission is again attributed to aggregated chlorophyll, while the band at shorter wavelength is assigned to the monomer. The slight shift in wavelength of this latter band with temperature is observed also in chlorophyll solutions in vitro (*3*), and is probably due to Franck-Condon effects.

In general, at low temperature (with, typically, 436 mμ excitation), the intensity of fluorescence from the chlorophyll aggregate relative to that from the monomer increases with increasing age of the algal culture or leaf, until a stable ratio is reached. In the case of *Ochromonas, Chlorella,* and the higher plants, the final relative (uncorrected) intensities of the two low-temperature bands are roughly equal (Fig. 1).

In another group of algae, the low-temperature aggregate emission in mature cultures far exceeds the monomer emission. This is the case, for example, in *Euglena* (Fig. 2) and *Porphyridium*. Direct measurements of absorption spectra of *Euglena* at room and liquid nitrogen temperatures show surprisingly little difference and rule out the possibility that the observed fluorescence changes are artifacts, due to selective reabsorption of fluorescent light. In these algae, we have confirmed the observations of French that, indeed, even the room-temperature fluorescence spectrum shows marked broadening, shifts in peak location, and appearance of shoulders, as the culture ages (*10*). Such effects, found to a lesser degree also in the other green plants, may arise from a sufficiently strong aggregate emission in mature cultures to be observable even at room temperature. It is noteworthy that in *Porphyridium*, in which such large amounts of aggregated chlorophyll are found, the long-wavelength decrease in photosynthetic efficiency begins at about 650 mμ (*7*), whereas in algae of the first group, as typified by *Chlorella*, the decline sets in at about 685 mμ (*6*).

Several explanations are possible for the enhancement of long-wave fluorescence at low temperature. As pointed out earlier (*3*), cooling may cause an

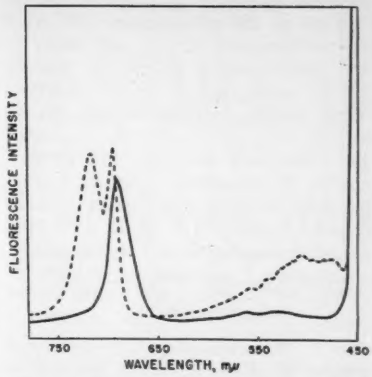

Fig. 1. Fluorescence spectra of 2-week culture of *Ochromonas danica*, at room temperature (solid line) and liquid nitrogen temperature (broken line). Excitation, 436 mμ. Spectra in Figs. 1, 2, and 3 are uncorrected for variation in photomultiplier sensitivity (Du Mont, 6911). Increased scattering, resulting from freezing of the algal suspension, makes the fluorescence yield at the lower temperature appear smaller than it actually is.

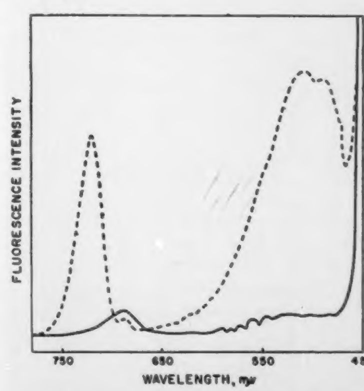

Fig. 2. Fluorescence spectra of 48-hour culture of *Euglena gracilis*, at room temperature (solid line) and liquid nitrogen temperature (broken line). Excitation, 436 mμ. In older cells the monomer band is difficult to detect because of the great height and breadth of the aggregate band.

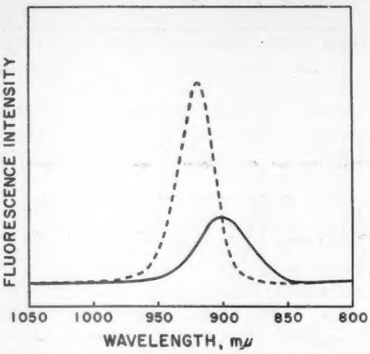

Fig. 3. Fluorescence spectra of 48-hour culture of *Rhodospirillum rubrum*, at room temperature (solid line) and liquid nitrogen temperature (broken line). Excitation, 365 mμ.

increase in aggregate concentration due to reversible association, or competing deactivation processes may be prevented. Another possibility is that low temperature may enhance energy-transfer processes into the aggregate from other pigments, by virtue of changes in relative molecular configuration, an increase in lifetime of the monomer excited state, or the shift to longer wavelength of the monomer luminescence. However, the most likely explanation seems to us to be a decrease in competing deactivation processes as the temperature is lowered.

In contrast to the situation in green plants, the various bacteria examined here show only one band in the low-temperature fluorescence spectrum, within the range of our fluorometer. This band is shifted about 20 mμ to longer wavelength, from the position of the room-temperature emission. The spectral sensitivity of the fluorometer was such that fluorescence bands as far out as 1020 mμ would have been detected, if their intensity were of the same order of magnitude as the single band observed at 910 mμ. We conclude, therefore, that only one type of fluorescent chlorophyll is present in the bacteria studied. This result is in agreement with the conclusions of Duysens, based on room temperature fluorescence data (*11*). Whether the single emitting state in bacteria corresponds to monomeric or aggregate bacteriochlorophyll is still uncertain. Experiments in vitro and lifetime measurements are in progress to establish this.

The differences noted here between the behavior of green plant and bacterial chlorophyll systems are especially intriguing, in view of the differences in the photosynthetic processes found in these two types of organism. Thus, one may suspect that the participation of two distinct fluorescent levels is needed for evolution of molecular oxygen, whereas the availability of only one such state can carry photosynthesis only to the level of an oxidizing agent intermediate between water and oxygen.

We draw attention (Figs. 1 and 2) to the fluorescence band near 515 mμ, which we believe is due to carotenoid emission. Excitation and emission spectra of *Euglena* in this region are similar to those of EPA solutions of antheroxanthin (*12*).

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References and Notes

1. A. A. Krasnovsky, K. K. Vojnovskaya, L. M. Kosobutskaja, *Doklady Akad. Nauk S.S.S.R.* **85**, 389 (1952); A. A. Krasnovsky and L. M. Kosobutskaja, *ibid.* **91**, 343 (1953).
2. E. E. Jacobs, in "The photochemical apparatus," *Brookhaven Symposia in Biol. No. 11* (1958).
3. S. S. Brody, *Science* **128**, 838 (1958).
4. J. Lavorel, *J. Phys. Chem.* **61**, 1600 (1957).
5. S. S. Brody and M. Brody, *Nature*, in press.
6. R. Emerson and C. Lewis, *Am. J. Botany* **30**, 165 (1943).
7. M. Brody and R. Emerson, *J. Gen. Physiol.* **43**, 251 (1959).
8. R. Emerson and E. Rabinowitch, *Plant Physiol.* **35**, 477 (1960).
9. The apparatus used in the present work will be described elsewhere.
10. C. S. French, in "The photochemical apparatus," *Brookhaven Symposia in Biol. No. 11* (1958).
11. L. N. M. Duysens, thesis, University of Utrecht (1952), p. 27.
12. We would like to thank Dr. Norman Krinsky of Tufts University for kindly providing a sample of crystalline antheroxanthin. This work was supported by grants to Brandeis University from the National Science Foundation (G-6418) and the U.S. Atomic Energy Commission [AT(30-1)-2003].

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Use of a Computer to Evaluate Alternative Insecticidal Programs

Abstract. A simple numerical routine which mimics the effects of density-dependent factors and weather has been used to simulate insect pest population trends without control, and with a variety of insecticidal procedures. Results of the analysis suggest that apparent benefits from spraying are illusory, since spraying elicits homeostatic response by the pest population.

In the last few years there has been great interest in novel techniques for insect pest control: species-specific sex attractants to lure adult male insects to a demise which precludes copulation (*1*), and manipulation of genetic composition of natural populations by releasing radiation-sterilized (*2*) or foreign (*3*) males. Two reasons for this concern with novel control methods are the failure of insecticides and the spectacular success of the program to control screwworms by mass release of radiation-sterilized males (*2*). In view of the variety of insect pest control procedures available and the amount of money at stake in crops and forests, it would seem worthwhile to attempt construction of a mathematical theory of pest control. Such a theory should be designed to indicate the best type of control, or combination of types of control, for any situation, how to time control, and how intensive control should be for optimum effects.

There are a few well-documented cases showing what happens to a pest that has in fact been effectively controlled: it becomes extinct (*2*) or it persists at a very low level (*4*). With these cases as the standard of ideal control, it is clear that insecticides do not constitute ideal control. Failure of insecticide control has been attributed generally to selection of resistant strains (*5*), physiological stimulation by sublethal doses (*6*), and elimination of entomophagous species (*7*). However, perhaps there is a more basic explanation than any of these: use of insecticides reduces intraspecific competition pressure to such an extent that increased fecundity, fertility, and survival rates compensate, or more than compensate, for the drop in population (*8*).

As a first step in devising a mathematical model to compare the long-term effects of various control procedures, I have developed a simple numerical routine with which a computer can simulate pest population trends. N_i represents the number (per unit area) of adults in the *i*th generation; $N_{i+1/2}$ represents the number of larvae present at the end of the third instar (that is, after half the larval growing stage has been completed); D_i represents the average number of third-instar larvae surviving per adult under average weather conditions; D_i^1 represents the average number of adults surviving per third-instar larva under average weather conditions; S represents the proportion of third-instar larvae surviving spray treatment; and W_i is a factor by which the D_i and D_i^1 values must be multiplied to express the effect of weather in the *i*th generation. Then

$$N_{i+1/2} = N_i\, D_i\, W_i \qquad (1)$$

$$N_{i+1} = N_{i+1/2}\, D_i^1\, W_i\, S \qquad (2)$$

D_i is computed from the empirical formula

$$D_i = \frac{C_7}{N_i}\left[1.0-\exp\left\{-N_i \times \frac{(C_1+\exp[C_2-C_3 N_i])}{C_4+\exp(C_5-C_6 N)}\right\}\right] \qquad (3)$$

where the *C*'s are constants. Arguments in support of this general form for D_i are given elsewhere (*8*). D_i^1 has the same form, but a different set of

parameters, and N_i is replaced by $N_{i+\frac{1}{2}}S$. Values for the parameters in D_i and D_i^1 were chosen so as to obtain biologically realistic curves. Empirical studies show that, in plots of D_i^1 against $N_{i+\frac{1}{2}}$ D_i^1 falls off above a maximum because of intraspecific competition and below the maximum because predators remove an increasing proportion of the pests as numbers of the pest decrease to very low levels (*9*).

The computer simulates population behavior for 100 generations, each *i*th generation taking the W_i from a table of 100 W values which has been constructed from Canadian weather records and survival versus temperature data in the literature. For each set of 14 parameters in D_i and D_i^1, several series of data are obtained. In one series, data are obtained for 100 generations in which the population is unsprayed (that is, $S = 1.00$). In other series $S = S_1$ whenever $N_{i+\frac{1}{2}} \geqq B$, some predetermined value at which the insect density has risen to a "pest" level. Data from 100 generations are obtained for each of the various combinations of S_1 and B values.

The general conclusion from these simulation studies is that insecticides do not, according to this model, depress pest population level as much as one would expect, and for some combinations of parameters, sprayed populations exceed unsprayed controls, due to the homeostatic response of the population. For example, in one run for which $S_1 = .01$ and $B = 2048$, the average N_i value over the "century" was 57 percent of the control N_i average, and N_i for the sprayed population exceeded N_i in the control population in 34 out of 100 generations. In no case examined did 99 percent spray kill result in a population equilibrium level as low as 1.0 percent of the control equilibrium level. The lowest population level produced by any spray program was 37 percent of the corresponding control population equilibrium level. It should be noted that the capacity for population recovery after spraying as assumed in this model is less than that in nature because the effect of selection for spray resistance is not included in the model.

In view of the importance of the indications from this primitive model, it would seem worthwhile to collect field data in order to check these findings (*10*).

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References and Notes

1. N. Green, M. Beroza, S. A. Hall, *Advances in Pest Control Research* **3**, 129 (1960).
2. A. W. Lindquist, *J. Econ. Entomol.* **48**, 467 (1955).
3. J. A. Downes, *Can. Entomologist* **91**, 661 (1959).
4. R. W. Smith, *ibid.* **91**, 697 (1959).
5. A. W. A. Brown, *Insecticide Resistance in Arthropods* (World Health Organization, Geneva, 1958).
6. D. J. Kuenen, *Entomol. Exptl. Appl.* **1**, 147 (1958).
7. H. E. Hinton, *Sci. Progr.* **43**, 634 (1955).
8. K. E. F. Watt, *Can. Entomologist* **92**, 674 (1960).
9. R. F. Morris *et al.*, *Ecology* **39**, 487 (1958).
10. I am indebted to W. A. F. Hamm and K. W. Smillie for assistance in preparation and improvement of the electronic computer program, and to Mrs. P. M. Morse and P. Robinson for helpful discussions.

31 October 1960

Diffusion-Precipitin Index to Antibody Avidity

Abstract. Antigen, diffusing into converging edges of an antibody depot, inhibits the precipitation unless the reaction is completed before an inhibiting antigen excess is established. Since the rate of the increase of antigen concentration depends on the size of the angle, relative avidities of similar preparations of antibody may be estimated from the angle just producing observable inhibition.

An analogy is sometimes drawn (*1*) between the densitometric distribution of precipitate along the axis of an Oudin tube and the precipitin curve of the system producing a zone of precipitate in that tube. The gradient of antigen concentrations ranging from a maximum in the fluid layer to a minimum at the momentary site of the plane, in advance of the zone, where antigen encounters free antibody, may be compared to the stepwise increments of antigen in successive tubes in a typical quantitative precipitin study.

The experiment shown in Fig. 1 demonstrates that the analogy is not a perfect one. Two small vessels, the shape of which has been found to be irrelevant to this experiment, were filled with agar containing 0.01 percent hen ovalbumin (*H*). Approximately equal areas were cut from the center of each vessel, and the agar removed was replaced with agar containing rabbit anti-hen ovalbumin precipitin sufficiently diluted to allow the zone which formed to migrate toward the center of the plate.

In the upper triangular vessel, antigen diffusing into the circular antibody depot advanced as an expanding gradient evenly distributed about the periphery. The deposited precipitate, which was not readily redissolved in antigen excess with this particular serum, was observed as a correspondingly uniform, broadening zone.

In the lower vessel, the same concentrations of antigen must have passed through each point in the region marked by precipitate as have passed through corresponding points in the circular antibody depot. Yet, the precipitate was not evenly distributed when the antibody depot had the triangular shape. The difference between these two arrangements lies in the rate at which the antigen concentration increased at certain points within the antibody depot, rather than in the actual antigen-antibody ratios established.

With fluid precipitin tests, when one uses a stepwise increment of antigen concentrations from tube to tube, no such time factor is involved. Inhibition of precipitation in antigen excess is due to failure to produce a precipitate, rather than to the erosion of precipitate previously formed as in the trailing edge of a zone in the Oudin tube. While the densitometric patterns produced by the Sami (*2*) scanning device resemble precipitin curves and have similar significance, they result from the solubility of precipitate in excess antigen, rather than from the prevention of precipitate deposition. Only in instances where precipitate formation was perfectly reversible would the suggested analogy be entirely valid.

In the lower plate in Fig. 1, antigen arriving in certain areas simultaneously from two interfaces has led to the establishment of inhibiting concentrations. The precipitate distribution in the upper plate shows that precipitate, once formed with this particular precipitin, is not readily redissolved by these same concentrations. The wedge-shaped areas in which precipitate is less dense or absent must therefore result from the effect of antigen arriving in the interval between the initial antigen-antibody combination and the

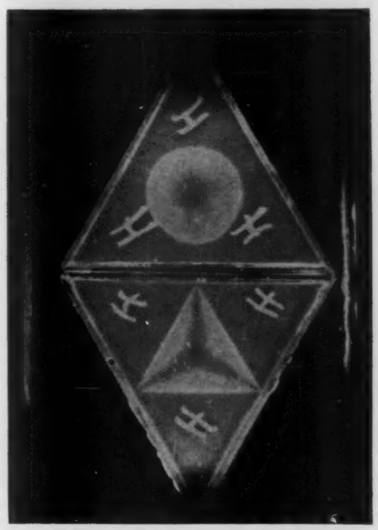

Fig 1. Agar plates containing hen ovalbumin diffusing from regions marked *H* into approximately equal volumes of rabbit anti-hen ovalbumin precipitin in agar in centrally located depots.

completion of the second stage of the precipitin reaction.

The following device may therefore be used as a means of carrying out rapid, rough estimates of the avidities of antisera which are identical to each other in specificity. A small plate of convenient shape may be filled with agar containing a standard antigen preparation. A polygonal depot may be cut or cast in the center of this agar, and refilled with agar containing the serum which is to be examined. We have found it convenient to form the antigen agar about a plastic die of the shape shown in Fig. 2, having the following angles. At the bottom of the heart-shaped figure, the angle is 90°. In ascending order along one side, the angles are 170°, 140°, 130°, and 100°. In the same order along the other side, the angles are 160°, 150°, 120°, and 110°. When the antigen-agar has hardened, this template is carefully withdrawn and the depression is filled with the serum agar. Tests should be run to determine a suitable dilution of serum, which permits the formation of an easily visible zone migrating rapidly into the antibody depot.

No precipitin system examined thus far has failed to show a wedge of clearing within the 90° angle; none has shown such a wedge with the 170° angle adjacent to it. Seemingly identical sera, in other respects, do, however, differ with respect to the angle in which clearing can just be seen, within this range.

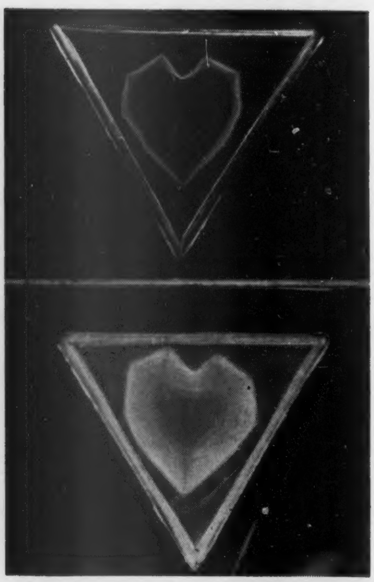

Fig. 2. Polygon plate studies of antibody avidity. Upper plate, hen ovalbumin, rabbit anti-hen ovalbumin system, after 18 hours of diffusion. Maximum angle in which inhibition could be observed, 130°. Lower plate, complex precipitating system illustrating unsuitability of method for comparison of heterospecific precipitins.

In the plate at the top in Fig. 2, it is demonstrated that wedges of inhibition can be observed after diffusion of 18 hours or less in favorable instances. The prolonged diffusion, giving rise to zones as wide as those shown in Fig. 1, is never necessary.

The lower plate in Fig. 2 has been included to emphasize the fallacy of attempting to make comparisons from one precipitin system to another by this method. A complex precipitating system (*3*) composed of 10 parts of hen ovalbumin to 1 of duck, diffusing into rabbit anti-hen-ovalbumin serum, was used to produce two zones.

The angle of inhibition of the homologous system, producing the zone closer to the peripheral antigen source, was found to be 140°. The wedge of inhibition could only be seen within the 90° angle in the case of the heterologous, cross-reacting system producing the inner band of precipitate. It would not be justifiable to conclude that the cross-reacting portion of the precipitin entered into a firmer union with the heterologous antigen than did the total precipitin with the antigen responsible for its production. Homologous, as well as heterologous, antigen is present in the area occupied by the proximal zone, but the leading edge of this zone marks the greatest excursion of the homologous antigen into the agar at the time of observation. The forces tending to reverse the two reactions differ, and no comparison is possible.

The method thus describes avidity of the antibody only in a relative sense. In a broader sense, avidity is the result of forces exerted between antigen and antibody and is not a characteristic of the antibody alone. The angle of inhibition will not indicate the absolute avidity and cannot be used, for example, to compare the avidity of an albumin-anti-albumin system with that of a globulin-anti-globulin system.

On the other hand, the method offers a simple, rapid means for establishing the relative avidity of each of a series of precipitin preparations specific for a given standard antigen preparation examined under uniform conditions (*4*).

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References and Notes

1. E. L. Becker, *Federation Proc.* **12**, 720 (1953).
2. W. G. Glenn, *U.S. Air Force Rept. No. 57–37* (1957), p. 4.
3. D. Buchanan-Davidson and J. Oudin, *J. Immunol.* **81**, 484 (1958).
4. This report was supported by the Asthmatic Children's Aid Society.

14 November 1960

Variability in Male Stature as Function of Adolescent Maturation Rate

Abstract. Boys who mature very early and, to a lesser degree, those who mature later than average show less variation in stature than boys who are somewhat early in adolescent development. These variability differences are paralleled in the heights of the mothers and fathers except in the case of boys who mature very early; there is far less variability in height among these boys than among their parents.

Variability in height among boys increases gradually from birth to the onset of adolescence, shows a relatively abrupt increase during the adolescent growth spurt, and returns almost to preadolescent levels at maturity (*1*). The peaking during adolescence is clearly attributable to wide variation in the ages at which boys enter this growth phase and to the rates at which they proceed toward physical maturity during this period. At physical maturity, however, residual differences in stature are presumably of genetic origin (disregarding the minimal contribution of nutritional differences), and therefore no systematic relationship between dispersion in mature height and maturation rate is to be expected.

A sample of 78 boys, born in 1928–29, was drawn from the University of California Guidance Study ($N = 64$) and from the Berkeley Growth Study ($N = 14$), the sole criterion being availability of complete records of physical development from birth to age 18 years (*2*). Age at reaching 90 percent of mature height ($M = 13.6$ years, $\sigma = 0.96$) was taken as the measure of maturation rate during adolescence (*3*), mature height itself ($M = 180.1$ cm, $\sigma = 6.6$) being defined as height at approximate skeletal maturity (*4*).

Figure 1 presents the relationship of variability in mature height to maturation rate. The probability that this degree of variation in σ among maturational groups is due to sampling fluctuations from a common population is .04 (by the Bartlett test for homogeneity of variance), and if we consider that this test does not take into account the rather regular trend of the data, even greater confidence may be placed in the reliability of this relationship. This result is not a product of development *during* adolescence, since a replication of this analysis with height data for age 9 (well before there is any evidence of pubescence in even the earliest-maturing group) provides a closely similar result. Here the relationship is even more clearly a non-chance outcome ($P < .001$). The two results are, of course, not independent (about 75 percent of the total-group variance in height at maturity can be predicted from the age 9

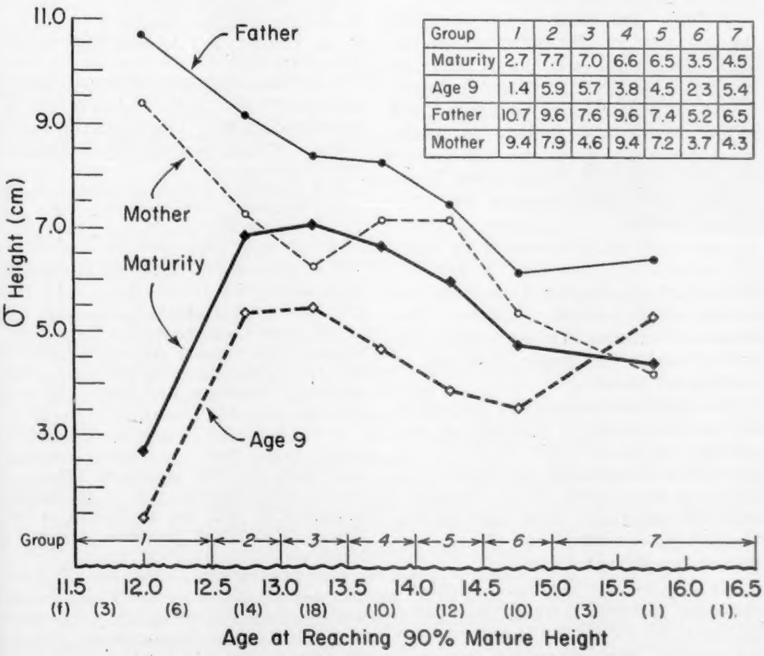
data), but it is apparent that variability differences among maturational groups predate adolescence.

One hypothesis to account for these results is that they stem from corresponding variability differences in the heights of one or both parents. This expectation is largely supported. Working with the heights *reported* by 63 sets of parents from the Guidance Study subgroup (for fathers, $M = 176.3$ cm, $\sigma = 8.3$; for mothers, $M = 163.1$ cm, $\sigma = 7.4$), we find that, for both parents, the plots of the σ-values against the sons' maturational rates closely resemble the boys' curves except for boys in the earliest-maturing group; the striking homogeneity for this group has no counterpart in the corresponding parental heights (Fig. 1). This finding, of course, does nothing to clarify the mechanism responsible for the relationship between maturation rate and variability, but the focus of speculation is shifted.

A possible, though unlikely, explanation of the low variability in stature of boys who mature early would be that, in this group alone, parental heights are *negatively* correlated, the usual homogamy with respect to stature being reversed. If this were so, and since predicted heights of offspring are essentially an average of the heights of the two parents (relative to their sex) (*5*), there would be less variability in height among the sons of these parents than among the parents. This is not the case: the between-parents height correlation is positive for this as for the other maturational groups. With this possibility ruled out, we infer that there is some attenuation, for the boys who mature earliest, of the hereditary factor. Thus, multiple-regression predictions, from parental stature, of mature heights of sons would be more in error for boys who mature early than for the remainder of the sample (*6*). Groups 1 and 2 in Fig. 1 represent boys who matured early. Data for these groups ($N = 20$) were combined, and predicted mature heights and squared deviations of the predicted heights from the true heights were computed. Similar calculations were made for a combined average-late maturational group ($N = 43$). The standard error of estimate for the group that matured early is 6.1 cm (yielding an estimated R of .53); for the others, the corresponding values are 4.8 cm and .75, respectively, indicating considerably greater predictive accuracy for the latter group. This result leads us to speculate that a common mechanism may underlie both maturational acceleration and this partial breakdown in the usual pattern of inheritance of stature.

Many more observations are of course necessary before it can be concluded that any of the several results point reliably to a population difference. Since even the relationships of maturation rate with boys' variability in stature, while most firmly based, require replication, we hope that evaluation of these preliminary findings will be undertaken in other growth studies.

NORMAN LIVSON
DAVID MCNEILL
Institute of Human Development, University of California, Berkeley



Group	1	2	3	4	5	6	7
Maturity	2.7	7.7	7.0	6.6	6.5	3.5	4.5
Age 9	1.4	5.9	5.7	3.8	4.5	2 3	5.4
Father	10.7	9.6	7.6	9.6	7.4	5.2	6.5
Mother	9.4	7.9	4.6	9.4	7.2	3.7	4.3

Fig. 1. Variability in height as a function of adolescent maturation rate. Extreme class intervals have been combined, as indicated. The plotted points have been derived from an algebraic (moving-mean) smoothing of the tabulated original values.

References and Notes

1. This is a well-established generalization, most recently supported by N. Bayley and S. Pinneau [*J. Pediat.* **40**, 423 (1952)] and by R. D. Tuddenham and M. M. Snyder [*Physical Growth of California Boys and Girls from Birth to Eighteen Years* (Univ. of California Press, Berkeley, 1954), vol. 1, No. 2]; these are reports, respectively, from the Berkeley Growth Study and the Guidance Study—longitudinal investigations from which the data reported here, are drawn. We are indebted to the staffs of these studies whose assistance made this report possible.
2. For the Guidance Study subgroup, raw data and descriptions of the measurement schedule and procedures are presented in Tuddenham and Snyder [*Physical Growth of California Boys and Girls from Birth to Eighteen Years* (Univ. of California Press, Berkeley, 1954), vol. 1, No. 2]; for details on the other subgroup see H. E. Jones and N. Bayley, *Child Develop.* **12**, 167 (1941).
3. The choice of this measure was recommended by the findings of A. B. Nicolson and C. Hanley [*Child Develop.* **24**, 3, (1953)], whose factor analysis of 11 indicators of adolescent maturation rate in these males demonstrates that a single general factor can account for all reliable covariation and is best estimated ($r = .99$) by age at 90 percent of mature height.
4. Skeletal maturity was taken to be age 17.25 (Todd standards), as stringent a criterion of epiphyseal closure as considerations of adequate sample size would allow. If any growth in stature occurred beyond this point, the mean of fluctuating annual heights or the maximum of regularly increasing heights was taken as mature height. For 11 cases where measurement at maturity was missing but where height had been measured through late adolescence, mature height was predicted from the skeletal age tables of N. Bayley [*J. Pediat.* **28**, 49 (1946)]. The standard error of estimate of predictions of mature height made from this age range is less than 1 cm.
5. K. Pearson and A. Lee, *Biometrika* **2**, 357 (1903); N. Bayley, *J. Educ. Psychol.* **45**, 1 (1954).
6. The relevant height correlations for this prediction are as follows: father × mother, .30; father × son, .47; mother × son, .62; the multiple correlation (R) is .69, and the resultant standard error of estimate for the total group is 5.2 cm.

18 July 1960

Second Printing July 1960

AAAS Symposium Volume No. 52

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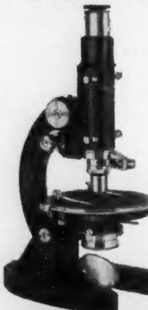

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Meetings

Stebinger Memorial Symposium

The First Stebinger Memorial Symposium was held at Northwestern University on 3 December 1960. The conference was attended by about 70 engineers and geologists from Canada, Mexico, and the United States.

The program emphasized foundation problems in surficial materials and included such topics as impregnation and consolidation of granular material by chemical methods such as cementing and clay grouting.

Emile Huni, chief engineer of the Soletanche Company in Vancouver, discussed methods of impregnating deep glacial alluvial fill in southern France and in northwestern Canada in order to render it impermeable. Joseph Ramos of the Halliburton Company spoke on chemical grouting, giving numerous illustrations of specific uses in dams and foundations. J. M. Edwards of the McCullough Tool Company discussed the gamma-gamma or density logging device, as developed for oil exploration, and considered its application in determining porosity and permeability in rocks or soils.

A lively discussion period occupied the last part of the morning session. This discussion was moderated by Shailer S. Philbrick, division geologist, Corps of Engineers, Pittsburgh, and visiting lecturer in geology at Northwestern University for the fall quarter of 1960. Parker D. Trask of the Engineering College, University of California, opened the discussion by bringing out recent developments in the study of water in sediments. Arthur B. Cleaves of Washington University, St. Louis, cited specific problems encountered in tunneling operations and pointed out some major problems in shutting off water.

The afternoon session was devoted to the legal aspects of engineering and geology as they affect decisions in landslide liability, water legislation, and the general problem of the responsibility of engineers. This part of the symposium was led by George A. Kiersch of Cornell University.

The late Eugene Stebinger, in whose honor the symposium was held, became affiliated with the United States Geological Survey after attending the universities of California and Chicago. Later he joined the Standard Oil Company (New Jersey) as chief geologist in Argentina and Bolivia, and later as president of the Standard Oil Company of Bolivia. On his return from South America he became chief geologist of Jersey Standard until his retirement in 1945. He died in 1951.

Mrs. Stebinger and her son Arnold, who is presently on the staff of Socony Mobiloil, donated Eugene Stebinger's library to the University of Illinois in Chicago, and the Standard Oil Company (New Jersey) established the Stebinger Memorial Fund with a substantial donation.

The symposium was arranged by Robert W. Karpinski in collaboration with J. Osterberg of the civil engineering department of Northwestern University and with the cooperation of A. L. Howland of the geology department. H. B. Gotaas and F. Trezise, deans of Northwestern and of the University of Illinois, respectively, attended the meetings.

It is anticipated that additional symposia will be held under the auspices of the Eugene Stebinger Memorial at two-year intervals, with emphasis on problems in the borderland between engineering and geology. Inquiries regarding future symposia are welcomed.

ROBERT W. KARPINSKI
University of Illinois, Chicago

Forthcoming Events

April

4–8. National Council of Teachers of Mathematics, 39th annual, Chicago, Ill. (F. A. Janacek, J. S. Morton High School, Cicero 50, Ill.)

5–8. Water Relations of Plants, British Ecological Soc., symp., London. (F. H. Whitehead, Botany Department, Imperial College, Prince Consort Road, London, S.W.7)

6–7. Council on Medical Television, annual, Bethesda, Md. (Institute for Advancement of Medical Communication, 33 E. 68 St., New York 21)

7–8. Eastern Psychological Association, Philadelphia, Pa. (C. H. Rush, P.O. Box 252, Glenbrook, Conn.)

7–9. American Assoc. for Cancer Research, 52nd annual, Atlantic City, N.J. (H. J. Creech, Secretary-Treasurer, Inst. for Cancer Research, Fox Chase, Philadelphia 11, Pa.)

7–9. Fleming's Lysozyme, 2nd intern. symp., Milan, Italy. (R. Ferrari, Organizing Committee, Via Modica 6, Milan)

8–9. Histochemical Soc., 12th annual, Atlantic City, N.J. (H. W. Deane, Albert Einstein College of Medicine, Bronx 61, N.Y.)

9–13. American Assoc. of Cereal Chemists, annual, Dallas, Tex. (J. W. Pence, Western Utilization Research & Development Division, 800 Buchanan St., Albany 10, Calif.)

9–13. American Industrial Hygiene Assoc., Detroit, Mich. (W. S. Johnson, Bethlehem Steel Co., Bethlehem, Pa.)

9–15. American Institute of Nutrition, Atlantic City, N.J. (A. E. Schaefer, ICNND, Bldg. 16A, National Institutes of Health, Bethesda 14, Md.)

10–14. American Soc. of Civil Engineers, Phoenix, Ariz. (W. H. Wisely, 33 W. 39 St., New York 18)

10–14. Detection and Use of Tritium in

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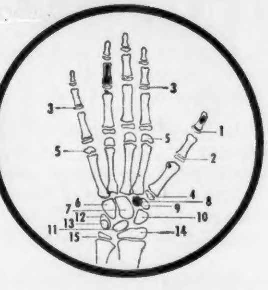
Status of ossification



This is part of a 37″ x 28″ chart we have put out. It may be useful to guide the gauging of physiologic age and metabolic status of children and adolescents by means of radiography. The chart gives other such radiograph tracings with similar data for the elbow, knee joint, foot and ankle, shoulder, hip joint, and fetal skeleton. Maturation schedule depends of course on nutrition, genetics, and, conceivably, climate. This particular chart is based on the experience of Dr. R. Hugo Mackay of University College Hospital in London with British youngsters.

HAND AND WRIST

1. **Distal Phalanx I, Epiphysis**
   Appears ♂1½Y ♀1Y
   Fuses 14–21Y
2. **Proximal Phalanx I, Epiphysis**
   Appears ♂3Y ♀2Y
   Fuses 14–21Y
3. **Phalanges II-V, Epiphyses**
   Appear 5M–2½Y
   Fuse 14–21Y
4. **Metacarpal I, Epiphysis**
   Appears ♂2½Y ♀1⅓Y
   Range ♂1½–3½Y ♀1–2Y
   Fuses 14–21Y
5. **Metacarpals II-V, Epiphyses**
   Appear 1–1½Y
   Range 10M–2Y
   Fuse 14–21Y
6. **Hamate**
   Appears 6M
   Range Birth–1½Y
7. **Capitate**
   Appears 6M
   Range Birth–1Y
8. **Trapezium**
   Appears ♂5Y ♀4Y
   Range 1½–10Y
9. **Trapezoid**
   Appears ♂6Y ♀4Y
   Range 2½–9Y
10. **Scaphoid**
   Appears ♂5½Y ♀4½Y
   Range 2½–9Y
11. **Lunate**
   Appears 4Y
   Range 6M–9½Y
12. **Pisiform**
   Appears ♂11Y ♀9Y
   Range 6½–16½Y
13. **Triquetrum**
   Appears ♂2¼Y ♀1¾Y
   Range 6M–4Y
14. **Radius, Distal Epiphysis**
   Appears 1Y
   Range 3M–1½Y
   Fuses to Shaft ♂19Y ♀17Y
15. **Ulna, Distal Epiphysis**
   Appears ♂6Y ♀5Y
   Range 4–9Y
   Fuses to Shaft ♂19Y ♀17Y

All told, we have had perhaps 50 suggestions from radiologists that we publish such a chart. Correlation between the good will of radiologists and the success of Kodak Blue Brand *and* Royal Blue Medical X-ray Film *is so high that 50 radiologists dropping casual comment on a subject over a span of years make a noise that sounds to us like an irresistible clamor. A student or other interested party who is not a practicing radiologist can obtain a notebook-punched 16½″ x 10″ version of the chart by request to Eastman Kodak Company, X-ray Division, Rochester 4, N. Y.*

The student who took advice

So much buy, buy, buy on all sides! Many a scientific man says the clamor is too overwhelming. Perhaps it is unwise to irk him further by suggesting that his own kind bears no small part of the credit for having caused the din to be set up.

In the early 1900s Sir William Ramsay, the physical chemist who discovered the noble gases, strongly advised a student of his named Mees to get a job in industry instead of following the traditional scientist's livelihood of teaching. The young fellow therefore went to work for Wratten & Wainwright, a small firm that made photographic plates. Actually, until not so long before, Mrs. Wratten, the senior partner's wife, had been making them in her kitchen, quite successfully flowing the emulsion from a teakettle onto glass.

But young Mees brought science into the operation. The union of science and industry was blessed with new products for Wratten & Wainwright. They attracted the attention of Mr. Eastman, of Kodak, who decided it would be good for *his* business, too, to apply some science to it. Instead of emulating Wratten & Wainwright, he bought their business and brought Mees to Rochester, N. Y., U.S.A., as Kodak's research director. This happened in 1912.

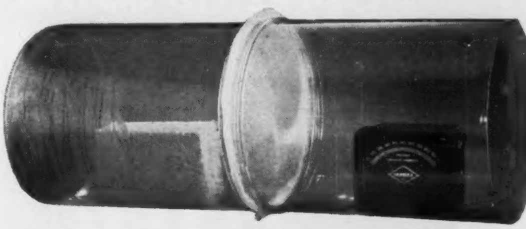
After 43 years in the job, Mees retired and wrote a book about his experiences in nurturing the chemistry and physics of one industry to churn out the stuff that has to be bought, bought, bought. His long, happy, and fruitful life ended last year. This month the book will be coming out under the title "From Dry Plates to Ektachrome Film" (Ziff-Davis Publishing Co., New York, $5.95 at many camera shops). It is recommended to those who want a very grown-up viewpoint on photography and its technology. It may also prove instructive to scientists in general who have made or are contemplating a switch from the world of scholarship to the world of commerce.

New and edible

The general public doesn't realize that we produce edible products with calories in them that a person can grow on and do pushups with. The newest of them bear the colorless designation "distilled acetylated monoglycerides." In front of the ungainly generic name we stick the trademark "Myvacet," which is easier to remember and shows we mean business. So far the business is confined to operating a small pilot plant and sending out technical salesmen to get food laboratories to accept samples with which to play and plan.

First the salesmen establish the distinction from *un*acetylated monoglycerides, another and equally real food which we have been producing by the ton for years as a texture-improver for fat-based foods and more recently for starch-based ones.

Then the salesmen undertake their mission of inspiration. They show this picture to fix in mind that "Myvacet" makes



a most effective barrier to water vapor. It also bars oxygen but not carbon dioxide. The solid "Myvacet, Type 5-00"* is far more flexible when cold than paraffin wax, which it resembles in feel and appearance but not in chemical nature.

The liquid "Myvacet, Type 9-40"** is a better gear and bearing lubricant, even under high pressures, than many petroleum-based products, yet, like the solid, it is unquestionably and officially*** edible and at the same time outlasts previously known edible oils against the forces of rancidity. As an intentional ingredient of shortening and table spreads, it makes their consistency almost independent of temperature. (As man inhabits more and more of the globe, he will need quite a few such ideas to keep himself in a good frame of mind.)

To send for our salesman and his samples, write Distillation Products Industries, Rochester 3, N. Y. (Division of Eastman Kodak Company.) Let him hint at new frontiers in fish-dipping, raisin-spraying, chicken-plucking, meat-freezing, and sealing the cut end of a hand of bananas so that the stalk can be left back at the plantation.

*A distilled monoglyceride of fully hydrogenated lard or cottonseed oil, with about half the glyceryl hydroxyls replaced by acetyl groups.

**A distilled monoglyceride of partially hydrogenated lard or cottonseed oil, with nearly all the glyceryl hydroxyls replaced by acetyl groups.

***United States Food and Drug Regulations, Sec. 121.1018.

Kodak
TRADE MARK

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

the Physical and Biological Sciences, intern. symp., Vienna, Austria. (Office of Special Projects, U.S. Atomic Energy Commission, Washington 25, D.C.)

10–15. Federation of American Societies for Experimental Biology, 45th annual, Atlantic City, N.J. (M. O. Lee, 9650 Wisconsin Ave., Washington 14, D.C.)

10–15. Metallic Corrosion, 1st intern. cong., London, England. (Society of Chemical Industry, 14 Belgrave Sq., London, S.W.1)

11–13. Institute of Environmental Sciences, annual, Chicago, Ill. (H. Sanders, Box 191, Mt. Prospect, Ill.)

11–13. Ultrapurification of Semiconductor Materials, conf., A.F. Office of Scientific Research, Boston, Mass. (Miss H. Turin, Conf. Secretary, Electronics Research Directorate, Air Force Cambridge Research Lab., L. G. Hansom Field, Bedford, Mass.)

12–13. Information and Decision Processes, 3rd symp., Lafayette, Ind. (R. E. Machol, School of Electrical Engineering, Purdue Univ., Lafayette)

12–14. Agglomeration, intern. symp., Philadelphia, Pa. (Metallurgical Soc. of the AIME, 29 W. 39 St., New York 18)

12–14. Chemical Soc., anniversary meeting, Liverpool, England. (Chemical Society, Burlington House, Piccadilly, London, W.1)

13–14. Society of Technical Writers and Publishers, 8th annual, San Francisco, Calif. (R. B. Meier, Head Editor, Engineering, Stanford Research Inst., 333 Ravenswood Ave., Menlo Park, Calif.)

17–18. Great Lakes Research, 4th conf., Ann Arbor, Mich. (C. F. Powers, Great Lakes Research Division, 1119 Natural Science Bldg., Ann Arbor)

17–19. Fluid Seal Meeting, intern., Ashford, Kent, England. (Information Officer, British Hydromechanics Research Assoc., South Road, Temple Fields, Harlow, Essex)

17–24. International Congress of Nurses, 12th quadrennial cong., Melbourne, Australia. (Miss D. C. Bridges, Secretary, 1 Dean Trench St., London, S.W.1, England)

18–20. Chemical Reactions in the Lower and Upper Atmosphere, intern. symp., San Francisco, Calif. (R. D. Cadle, Stanford Research Inst., Menlo Park, Calif.)

18–21. American Geophysical Union and Amerioan Meteorological Soc., Washington, D.C. (American Geophysical Union, 1515 Massachusetts Ave., NW, Washington 5, D.C.)

19–21. Southwestern Inst. of Radio Engineers Conf. and Electronics Show, Dallas, Tex. (SWIRECO 61, P.O. Box 7443, Dallas 9)

20–21. Society of Chemical Industry, fungicide symp., London, England. (B. J. Heywood, 103 Harrow Drive, Hornchurch, Essex, England)

20–22. Association of Southeastern Biologists, Lexington, Ky. (H. J. Humm, Department of Botany, Duke Univ., Durham, N.C.)

20–24. Microbial Reactions in Marine Environments, intern. symp., Chicago, Ill. (C. H. Oppenheimer, Inst. of Marine Science, Univ. of Texas, Port Arkansas)

21–22. American Assoc. of Univ. Professors, Boston, Mass. (W. P. Fidler, AAUP, 1785 Massachusetts Ave., NW, Washington 6, D.C.)

23. American Pharmaceutical Assoc., Chicago, Ill. (W. S. Apple, 2215 Constitution Ave., NW, Washington, D.C.)

23–26. American Assoc. of Colleges of Pharmacy, Chicago, Ill. (C. W. Bliven, George Washington Univ., Washington 6, D.C.)

23–27. American Ceramic Soc., 63rd annual, Toronto, Canada. (C. S. Pearce, 4055 N. High St., Columbus 14, Ohio)

23–27. Society of American Bacteriologists, Chicago, Ill. (E. M. Foster, 311 Bacteriology, Univ. of Wisconsin, Madison)

23–28. American Soc. of Hospital Pharmacists, Chicago, Ill. (J. A. Oddis, 2215 Constitution Ave., NW, Washington 7, D.C.)

24–26. Aerospace Medical Assoc., 32nd annual, Chicago, Ill. (W. J. Kennard, Secretary-Treasurer, c/o Washington National Airport, Washington, D.C.)

24–27. American Assoc. of Petroleum Geologists, Denver, Colo. (G. V. Cohee, U.S. Geological Survey, Washington 25, D.C.)

24–27. American Physical Soc., Washington, D.C. (K. K. Darrow, 538 W. 120 St., New York 27)

25–28. Society of Economic Paleontologists and Mineralogists, Denver, Colo. (J. Imbrie, Dept. of Geology, Columbia Univ., New York, N.Y.)

(See issue of 17 February for comprehensive list)

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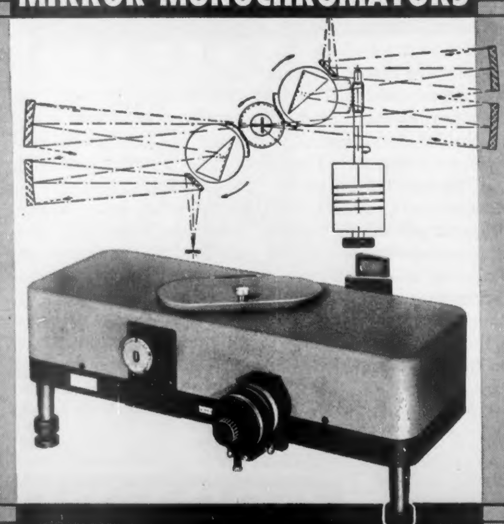

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* *In April 1960 issue of Lab World.*

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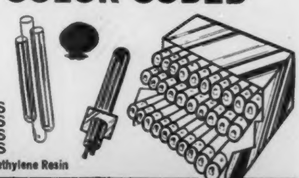

*DuPont registered trademark for Polytetrafluoroethylene Resin

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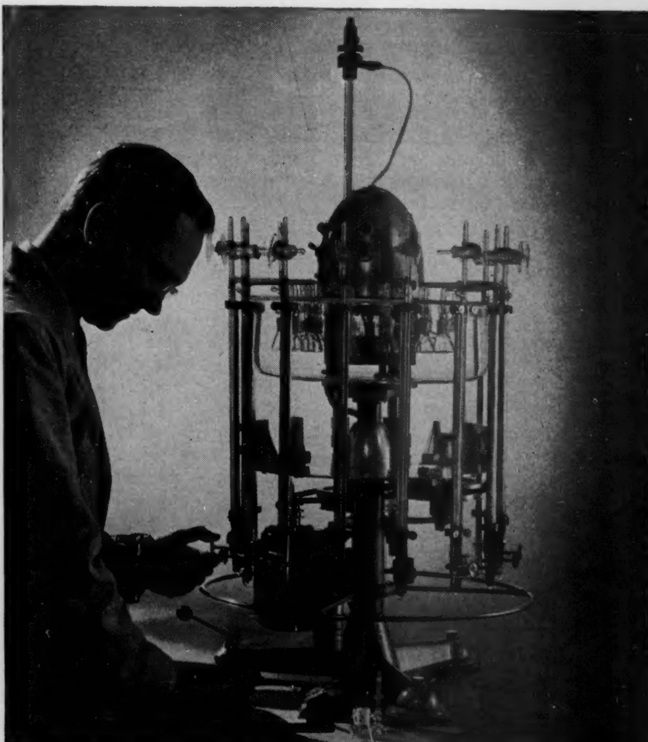

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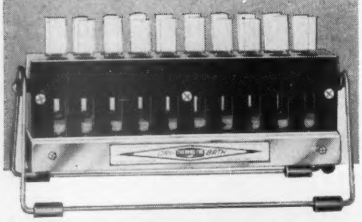

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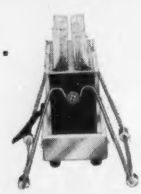

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New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Neither Science *nor the writer assumes responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to the manufacturer. Include the department number in your inquiry.*

■ CONTINUOUS GAS-DENSITY BALANCE consists of a measuring cell, amplifier, power supply, and temperature controls. The sensitive element in the gas-density sample cell is a dumbbell supported on a quartz fiber and constructed so that the two spheres have different buoyancy. A mirror fixed to the dumbbell's axis reflects a light beam to a dividing mirror and thence to two photocells. Rotation of the dumbbell results in an unbalance signal that is used to oppose the rotation. Two fixed-potential electrodes create an electrostatic field around one sphere. A variable potential obtained by amplification of the unbalance signal is applied to this sphere, which is made conductive by a coating of rhodium, to stabilize the dumbbell.

The measuring cell's response to changes in density is 95 percent in less than 1 min; response time of the complete system depends on the sample transit time through the sample-handling system. A meter on the front of the instrument indicates instrument response, and a signal is supplied to a standard potentiometric recorder to maintain a continuous record of variations in process-stream density. Meters are available in a choice of single ranges or in multiple ranges with a common end point. Minimum span is 0.01 full scale relative to air; maximum span is 2.0 full scale relative to air. Accuracy is said to be ±1 percent of full scale, sensitivity ±0.5 percent. Electrical output is 0 to 5 mv at 25-ohm impedance. Current or pneumatic outputs are also available. Sample flow rate is 48 in.^{3}/min at 10 lb/in.^{2} (gage) with pressure regulation or 3 to 15 in.^{3}/min without pressure regulation. Sample temperature range is 50° to 130°F. (Beckman Instruments, Inc., Dept. Sci85, 2500 Fullerton Rd., Fullerton, Calif.)

■ B-H METER graphically displays the hysteresis loop of tape or pigment on an oscilloscope. Measurements on samples as small as four strands of ¼-in. tape fall within the direct-reading calibrated range of the instrument; display adequate for qualitative inspection can be obtained from a single strand. Direct-reading calibrated range of sample flux is from 3 to 1000 max with a maximum sample-chamber diameter of ⅜ in. The instrument can measure coercive force and remanence or flux at an arbitrary point. (Scientific Atlanta, Inc., Dept. Sci102, 2162 Piedmont Rd., NE, Atlanta 9, Ga.)

■ HIGH TEMPERATURE FURNACE is designed for continuous operation at temperatures up to 4800°F and for intermittent use up to 5100°F. Working volume is 8 in. high and 4 in. in diameter. Atmospheric control in the working chamber is provided by a flow of helium or reducing gas for protection of the charge and graphite heating element. Graphite electrodes and aluminum exterior shell are water cooled; coolant flow rate is 1.5 gal/min at maximum temperature. Standard power supply is 16 kw, 3 phase, 440 and 220 volts. The furnace can be supplied with a saturable reactor and stepdown transformer to facilitate automatic temperature control. (Curtiss-Wright Corp., Dept. Sci93, P.O. Box 110, Princeton, N.J.)

■ ULTRASONIC IMPACT GRINDER can machine an area up to 1⅜ in. in diameter. The device features an air-cooled, 300-watt magnetostrictive transducer so that plumbing associated with water cooling is absent. The transducer is an insert type; either the coil or the transducer can be removed without disturbing the other. (Raytheon Company, Dept. Sci25, 1415 Providence Turnpike, Norwood, Mass.)

■ PARAMETRIC AMPLIFIER ASSEMBLY for the *S* band consists of a three-part ferrite circulator, a reflection-type diode amplifier, a pump klystron, a variable attenuator, and a directional coupler monitor. Typical specifications include a tuning range of 100 Mcy/sec, operating gain of 17 db, band width of 20 Mcy/sec at 3-db points, and system noise figure of 2.5 to 3.0 db, operating into a mixer with noise figure of 10 db. (Micromega Corp., Dept. Sci73, Venice, Calif.)

■ HIGH RESISTANCE BRIDGE measures resistance in the range 10^6 to 10^{15} ohms with accuracy said to be ±.05 percent up to 10^8 ohms, decreasing to ±0.25 percent at 10^{12} ohms and to ±1.0 percent at 10^{14} and 10^{15} ohms. An electrometer null detecter is an integral part of the instrument. Input resistance of the electrometer is greater than 10^{14} ohms; maximum voltage sensitivity is greater than 1 millivolt per division of deflection. Self-contained bridge potentials up to 10 volts are supplied by a transistorized power source. A remote test chamber with Teflon insulated triaxial cable is available for testing insulation or making other external measurements. One terminal of the resistance being measured is at ground potential. (Keithley Instruments Inc., Dept. Sci104, 12415 Euclid Ave., Cleveland 6, Ohio)

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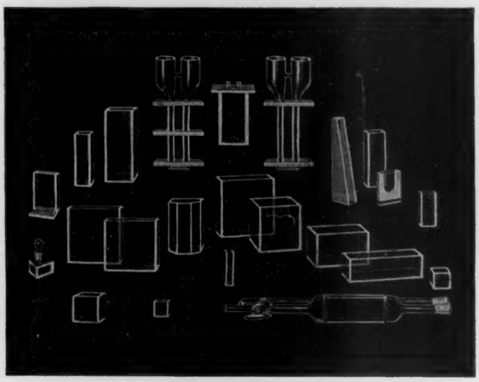

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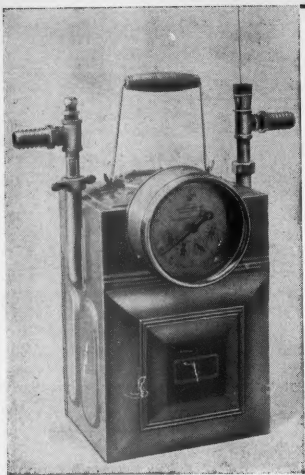

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Drv Test. Laboratory Model

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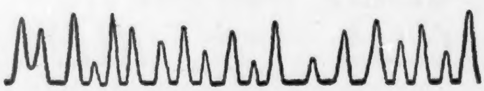

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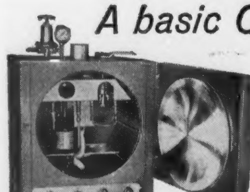

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Vertebrate Ecologist available for teaching, research or land management; 10 years' experience teaching and field work, in wildlife management, forestry, conservation education. Ph.D., zoology; master's, forestry. Franklin McCamey, Storrs, Conn. X

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Zoologist-Parasitologist, Ph.D., several years of teaching and research experience, publications, research grants, seeks teaching or research position. Box 50, SCIENCE. X

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BIOCHEMIST (Ph.D.) or PHYSIOLOGIST with background in intermediary metabolism and endocrinology for group participation in research program on mode of hormone action in 750 bed hospital located on Indiana University Medical Center campus. Active participation in University teaching program and opportunity for independent research. Salary depending on background. Career Civil Service. Write Personnel Officer. Veterans Administration Hospital, 1481 West Tenth Street, Indianapolis 7, Indiana.

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Four (4) years accredited college including thirty (30) semester hours of chemistry, plus 3 years of responsible and progressive experience, or Ph.D. Position is in the Career Civil Service. Duties involve 80 percent clinical laboratory work and 20 percent research. Contact William R. Crofts, Personnel Officer, Veterans Administration Hospital, Louisville, Ky.

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Applications are invited for the position Assistant Professor of Biology with specialization in Animal Physiology, Embryology and Histology.

Candidates with background and experience in Marine Biology will receive preference. Ph.D. or equivalent essential. Duties beginning September 1961, to include teaching and research. The starting salary will be based on qualification and experience.

Applications accompanied by complete curriculum vitae and the names of three references should be addressed to the **Head, Department of Biology, Memorial University of Newfoundland.**

Applications are invited for the position of **DIRECTOR** of the **Queensland Institute of Medical Research,** Brisbane, Australia. The duties are (1) to direct research work and control research staff of institute, (2) to continue to develop the institute on a comprehensive research basis, and (3) to plan the permanent housing of the institute. To date, research has been almost entirely in the field of communicable disease. The salary is £4583 per annum. Tenure is for 7 years, with eligibility for re-appointment. Technical and lay staff, other than term appointees, such as the Director, are subject to the Public Service Acts, and administration generally follows Public Service practice. Appointee will be required to commence duty as early as possible after 1 August 1961.

Applications close on *31 March 1961*, with First Secretary, Australian Legation to United States of America, Washington, D.C., from whom intending applicants should obtain application forms and further information. 3/3, 10

EDUCATIONAL PROGRAM FOR CAREER RESEARCH IN BIO-MEDICAL ENGINEERING:

Drexel Institute of Technology and the Presbyterian Hospital in Philadelphia offer co-ordinated programs in Bio-Medical Engineering requiring up to two years of study for life and physical scientists and one year for engineers to a Master of Science degree. Preliminary course work in mathematics, physics, and circuits prepares life scientists for more advanced work in engineering systems, data handling and electronics jointly with graduate engineers. Courses in anatomy, biology, biophysics and medical physics affords the engineer insight into biological systems. Team research at the Hospital provides experience in interdisciplinary collaboration. The next student intake will be July, 1961. Cost of education is covered by Heart Institute and Markle Foundation Grants. Pre- and post-doctorate stipends conform to NIH suggested ranges. More extended programs leading to a doctorate in a life science are planned in collaboration with other educational institutions. For information: **James W. Dow, M.D.**; Head, Department of Medical Instrumentation; **Drexel Institute of Technology; 15 North 32nd Street; Philadelphia 4, Pennsylvania;** EVergreen 2-6200, Ext. 497.

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